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# COMMANDER THIRD FLEET
# UNITED STATES PACIFIC FLEET

# COMTHIRDFLT
# TACMEMO
# 280-1-76

## REFRACTIVE EFFECTS GUIDEBOOK (REG)

UNCLASSIFIED

UNITED STATES PACIFIC FLEET
COMMANDER THIRD FLEET
FPO SAN FRANCISCO 96610

IN REPLY REFER TO:
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Ser N33/1374
22 September 1976

From: Commander THIRD Fleet
To: Distribution

Subj: COMTHIRDFLT Tactical Memorandum 280-1-76

Ref: (a) NWP 0
(b) CINCPACFLTINST 3510.2L
(c) COMTHIRDFLT TACMEMO 280-2-75

Encl: (1) COMTHIRDFLT TACMEMO 280-1-76, REFRACTIVE EFFECTS GUIDEBOOK (REG)

1. TACMEMO 280-1-76 is forwarded as enclosure (1) in accordance with references (a) and (b). The TACMEMO contains improved guidelines for exploiting the effects of atmospheric refraction on electromagnetic propagation. Procedures are provided for converting routine weather information received aboard ship to a measure of anticipated system performance. Although the guidelines and procedures are based on a number of simplifying assumptions, the REG is considered a step forward in the documentation of tactical exploitation of refractive effects.

2. Reference (c), "Interim Guidelines for Using Atmospheric Refractive Effects," is superseded and cancelled.

3. The essence of the REG is contained in Chapters 4 and 5. Once the appropriate refractive profile has been determined from Chapter 4, the decision maker will find all the applicable information concerning that profile on a single page in Chapter 5. The remaining chapters provide background information and instructions for use.

4. This TACMEMO will be revised as necessary. Lessons learned and recommendations are desired from all users, who are requested to forward significant case histories, with supporting environmental data when available, for analysis. Such reports should be forwarded to Commanding Officer, Naval Environmental Prediction Research Facility, with copy to Commander THIRD Fleet and Commanding Officer, Pacific Missile Test Center (Code 3253).

S. L. GRAVELY, JR.

Distribution:
(See TACMEMO 280-1-76, Page i)

COMTHIRDFLT TACTICAL MEMORANDUM

280-1-76

| | |
|---|---|
| TAC D&E Category: | Sea Control Operations: MultiThreat Environment |
| Descriptive Title: | Refractive Effects Guidebook (REG) |
| Source: | Commanding Officer, NAVENVPREDRSCHFAC, and Mr. Jay Rosenthal, Geophysics Division, Pacific Missile Test Center |
| Originator: | Commander THIRD Fleet |
| Promulgation Date: | 22 September 1976 |
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| Reference: | COMTHIRDFLT Tactical Memorandum 280-2-75 Interim Guidelines for Using Atmospheric Refractive Effects, dated 25 July 1975. |
| Applicable NWP: | NWP-33 Electronic Warfare (U) |
| Distribution: | (one copy unless specified) |

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| 22A | Fleet Commanders (3) |
| 24 | Type Commanders (3) (less 24G) |
| 26A2 | Amphibious Group Commanders (2) |
| 26F2 | DEPCOMOPTEVFORPAC |
| 26H2 | Fleet Training Group |
| 26OO | Fleet Electronic Warfare Support Group and Detachment |
| 28A2 | Carrier Group (2) |
| 28B2 | Cruiser-Destroyer Group (2) |
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| 28D2 | Destroyer Squadron (2) |
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| 42K2 | Attack Squadron |
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## PREFACE

Appreciation is expressed to the author of the Refractive Effects Guidebook, Mr. Jay Rosenthal of the Pacific Missile Test Center, Point Mugu, CA, and to the following for their contributions to its development and preparation: Mr. Paul Lowe, Head, Atmospheric Physics Department, NEPRF, project coordination and technical review; CDR George Lawniczak, USN, Environmental Effects Officer COMTHIRDFLT, technical review; Dr. Juergen Richter and Mr. Herbert Hitney, NELC, IREPS ray tracing; LCDR Daniel Lepore, NWSD, Asheville, NC, provision of facsimile charts and world-wide profile data; Mr. Charles Phillips, PACMISTESTCEN, profile selection, Mr. Stephen Bishop, NEPRF, editorial services; Mr. Mason Ridlen, Supervisor, Graphics Branch, NEPRF, graphics and production.

Monterey, CA
April 1976

CAPT R.C. SHERAR, USN
Commanding Officer
Naval Environmental Prediction
Research Facility

# 1. BACKGROUND

## 1.1 PURPOSE

The Refractive Effects Guidebook (REG), developed in response to a request by the Commander, Third Fleet, and under the sponsorship of the Naval Air Systems Command, is designed to provide the Fleet with an initial capability to tactically exploit large scale atmospheric refractive conditions. Using routine weather information available to Fleet units, the REG presents guidelines for planning the employment of radar, sensor and communications systems* according to existing and predicted refractive conditions that frequently cause unusual performance (termed "anomalous propagation").

The REG information system can be used by both sensor operators and operational commanders: Guidance for the understanding of observed conditions is provided for operators, while information to support tactical planning for systems employment is provided for commanders.

## 1.2 BASIC PROBLEMS

The phenomenon of atmospheric refraction is defined as the bending of radar and radio beams by layers of air through

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* Where 'radar' is mentioned specifically hereafter, the discussions also apply equally to other sensor and communications systems.

which they pass. These layers are caused by variations in humidity, temperature and pressure. Depending on the layer structure, radar coverage at a given time and place, for example, can be normal, greatly extended, or substantially limited.

Typical of the two extremes are two primary conditions known as <u>ducting</u> (or <u>trapping</u>) and <u>radar holes</u>. Existence of a duct may cause low-angle radar beams (within about one degree of the horizontal) to be trapped as if in a waveguide and thus transmitted far beyond the normal radar horizon. A radar hole, on the other hand, is an area rendered deficient in radar illumination because of refractive conditions that bend the beams away from it.

With a duct's greatly extended coverage, distant features that would not normally be detectable may actually be detected. A radar hole, however, may allow the virtually undetected approach of a rapidly closing threat. For example, approaching aircraft have been sighted visually before being detected by radar. Still another phenomenon attributable to atmospheric refractivity is the appearance of false radar targets. These are sometimes known as "ghosts" or "phantoms" and are occasionally seen racing across the radarscope at up to supersonic speeds.

Phenomena known as "evaporative ducts," which occur near the ocean surface, can cause additional refractive

conditions for specialized cases that should be considered by the operational commander. This type of ducting, however, is beyond the scope of the present discussion and will be addressed in subsequent updates.

## 1.3 EXAMPLES OF THE PROBLEM

Atmospheric refraction can be a problem in naval operations. As far back as World War II when radar was first introduced, widely varying ranges were frequently observed. At that time, procedures for tactically exploiting these conditions were generally unavailable. As recently as the Viet Nam experience, radar ghosts sighted in the Gulf of Tonkin were confused with attacking patrol boats and aircraft, causing operational emergencies and quick but futile reactions.

Anomalous radar propagation occurs over all maritime operating areas of the world, but they are most significant over the warmer subtropical and tropical oceans. Possibly the most distant surface targets ever detected by radar were points on the Arabian peninsula seen by a 200 mHz radar at Bombay, India, during the dry season -- a distance of about 1,500 miles. During the wet monsoon season, the same radar had difficulty seeing vessels only 20 miles away.

# 2. APPLYING REG TECHNIQUES

## 2.1 INTRODUCTION

It is not necessary to be a weather or refraction expert to use the REG procedure effectively. Given available weather information, the user merely matches these known or predicted conditions to one of the typical atmospheric cases described in REG (Sections 4,5). Examination of the selected case will reveal the typical coverage pattern appropriate to the specified conditions. Each case provides a typical refractivity profile and several ray trace diagrams which illustrate the coverage that can be expected at different altitudes between the surface and 20,000 feet.

## 2.2 IREPS

REG profiles and ray traces were produced by computer using the Navy's Integrated Refractive Effects Prediction System (IREPS). This system is being readied by the Naval Electronics Laboratory Center (NELC) in San Diego for introduction into the Fleet within the next few years.

The IREPS profiles and ray traces are accompanied by brief descriptive notes that interpret the diagrams and indicate the nature of surface-to-surface, surface-to-air, and air-to-air coverage that can be anticipated for each ray trace

condition. For each set of ray traces, hypothetical radars were located at altitudes of interest based on the refractive profile. (Bounced rays simulate reflection of radar energy from the surface.)

Each refractive profile, developed from actual weather data, describes significant refractive properties of the lower atmosphere typically encountered during operations at sea.

## 2.3 PROFILE SELECTION SUMMARY

The appropriate profile is selected by the REG user according to one of three types of available weather information: (1) message, (2) facsimile chart, or (3) actual measurements.

In the simplest procedure, a WEAX message received aboard ship prescribes by letter the profile (in Section 5) to be used.

The second technique requires onboard facsimile charts for the ship's area of interest. (Satellite photographs may ultimately add to the store of available data.) The meteorologist or aerographer's mate (AG) compares the charts to the indexed REG charts in Section 4 and determines which one most closely resembles the current synoptic situation for ocean area and time of year. Once the chart is identified as typifying existing or forecast conditions, he

locates the ship's position with respect to dominant weather features (e.g., proximity to the center of a high, ahead of or behind a front, etc.). Letters superimposed on the chart tell which profiles are to be used in the various operational areas of interest.

The third technique is used by Fleet units having the capability to measure refractivity values in the lower atmosphere by means of radiosondes or refractometers. Using an actual refractivity profile derived from these soundings, the meteorologist/AG determines the REG profile in Section 5 that most closely resembles the actual conditions. This matching determines profile letter, and the information presented may then be applied for operational guidance.

It is emphasized that only the highest level and most valid weather information available should be used in the REG procedure. Actual measurements are preferable to facsimile charts, for example, while charts are preferable to WEAX messages (see para. 2.7).

## 2.4 PLACE AND TIME

REG charts are indexed according to operating area and season of the year for ease of reference. These charts depict characteristic large scale weather patterns for each season in each area.

## 2.5 SELECTION PROCESS STEP-BY-STEP

Procedures for using REG vary according to type of weather information available (message; facsimile chart; actual measurement). They are described and illustrated as follows:

Technique 1: <u>WEAX Message</u>

Step 1. Obtain from the WEAX message the profile letter to be used. Turn to this profile letter in the REG.

Step 2. Obtain the expected coverage conditions from the ray traces and accompanying notes for the selected profile.

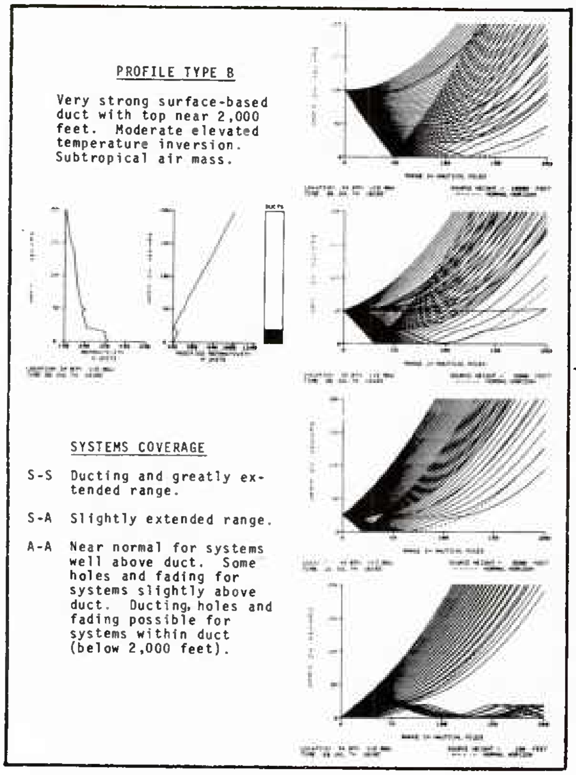
Figure 2-1. Example, Technique 1.

You have (step 1):

(Example)

231046Z JUN 78
FM FLEWEACEN PEARL HARBOR HI
TO RHWWAZMA/USS FLAGSHIP
INFO RUWJAGE/FLENUMWEACEN MONTEREY CA
RHHMERA/COMSERVPAC PEARL HARBOR HI
RHHPRAP/COMTHIRDFLT
BT
UNCLAS // NO3145 //
WEAX
A. USS FLAGSHIP 222019Z JUN 78
1. METEOROLOGICAL SITUATION AT 230600Z.
HIGH PRESSURE CNTR NR 40N 153W RIDGES SOUTHWEST TO NORTH BAJA COAST.
2. 24 HOUR FORECAST COMMENCING 231800Z ALONG TRACK FROM SAN DIEGO TO 33N 124W AS INDICATED REF A.
A. WEATHER: MSTLY CLDY W/NIGHT/EARLY MRNG HAZE AND FOG.
B. VSBY: UNRESTRICTED XCPT 2-4 MI IN HAZE AND FOG.
C. WIND: NORTHWEST 15-20 KTS BCMG NORTHERLY 12-16 KTS BY END OF PERIOD.
D. SIGNIFICANT WAVE: NORTH NORTHWEST 6-8 FT, 5-7 SECONDS.
E. REFRACTIVE PROFILE: B
3. OUTLOOK TO 48 HOURS: CONT CLDY, WIND NORTH 10-20 KTS GRADUALLY VEERING TO NORTHEAST. SIG WAVE NORTH 5-8 FT, 6-8 SECONDS.
BT

You get (step 2):



Technique 2: Facsimile Charts

Step 1. Locate the general proximity of the ship relative to the major weather features shown on the available charts.

Step 2. Examine the REG chart appropriate for the particular operating area and season.

Step 3. Transfer to the selected REG chart the position of the ship relative to the dominant weather features (established on the facsimile chart in step 1). Do not be concerned with latitude, longitude or other geographical considerations.

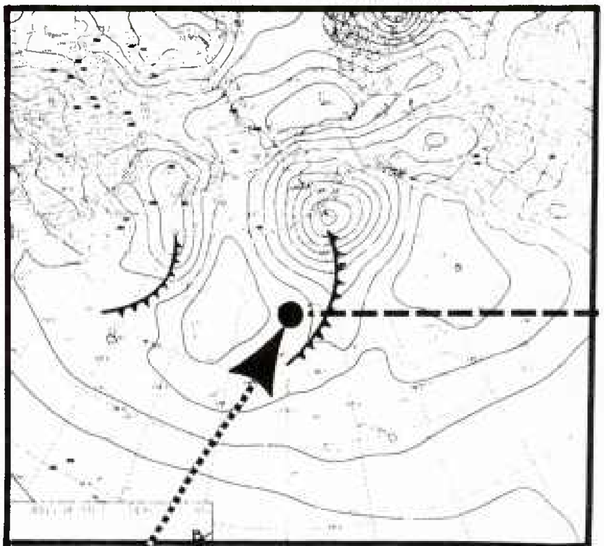
Step 4. Read the appropriate profile letter from the REG chart near the location chosen in Step 2. Turn to this letter in the REG.

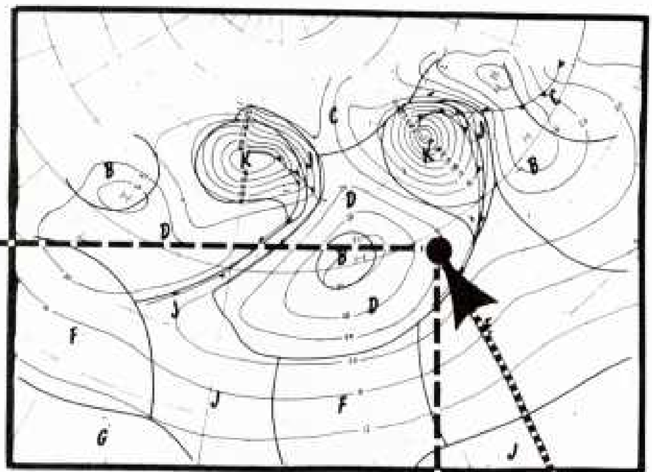
Step 5. Obtain the expected coverage conditions from the ray traces and accompanying notes for the selected profile.

Figure 2-2. Example, Technique 2.

You have (step 1):

You choose (steps 2-4):

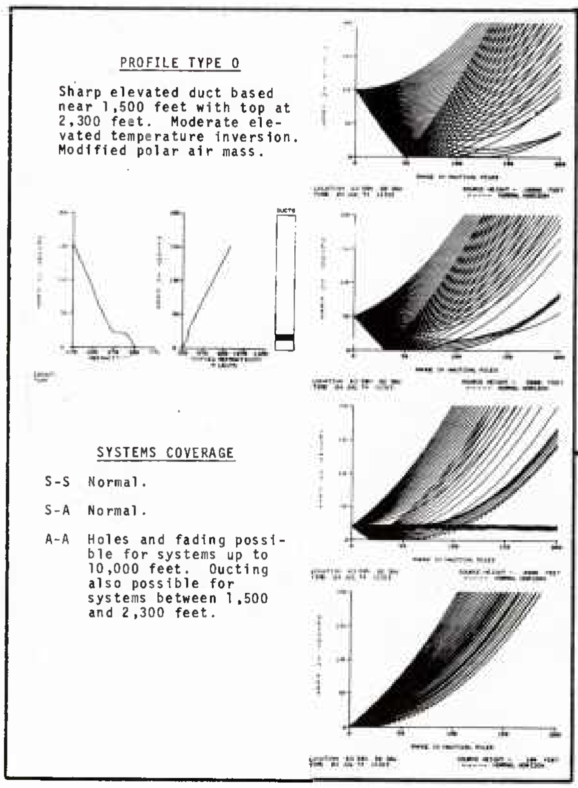




Actual or Predicted Ship Location

Ship Location Relative to Synoptic Features as Observed on Facsimile Chart

You get (step 5):


PROFILE TYPE O

Sharp elevated duct based near 1,500 feet with top at 2,300 feet. Moderate elevated temperature inversion. Modified polar air mass.

SYSTEMS COVERAGE

S-S Normal.

S-A Normal.

A-A Holes and fading possible for systems up to 10,000 feet. Oucting also possible for systems between 1,500 and 2,300 feet.

Technique 3: <u>Actual Refractive Profile Available</u>

Step 1. Locate the REG profile which most closely resembles the measured profile. In this matching process, refractivity profiles should be inspected for the following features:

(a) Are there any potential trapping layers? (The refractivity "N" must <u>decrease</u> at the <u>rate</u> of at least 48 N Units per 1000 feet of ascent over a height interval of at least 30 feet.)

(b) At what approximate altitude does such a layer occur?

(c) Are there two or more such layers?

(d) Are there any subrefractive layers? ("N" must <u>increase</u> with height over a height interval of at least 30 feet.)

(e) What are the approximate heights of these layers?

(f) Are there multiple ducts and subrefractive layers occurring together?

(g) Are there no trapping layers or subrefractive layers at all?

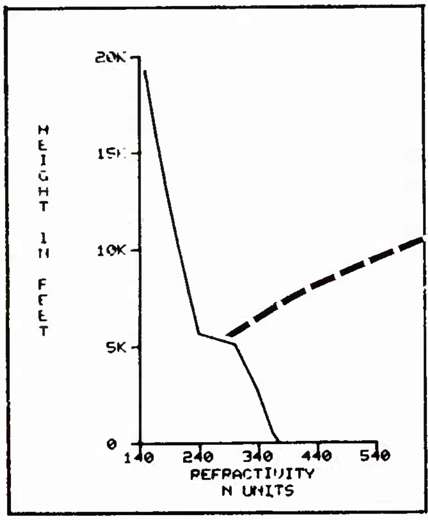
(h) Does the temperature profile indicate warm or cool temperatures near the surface?

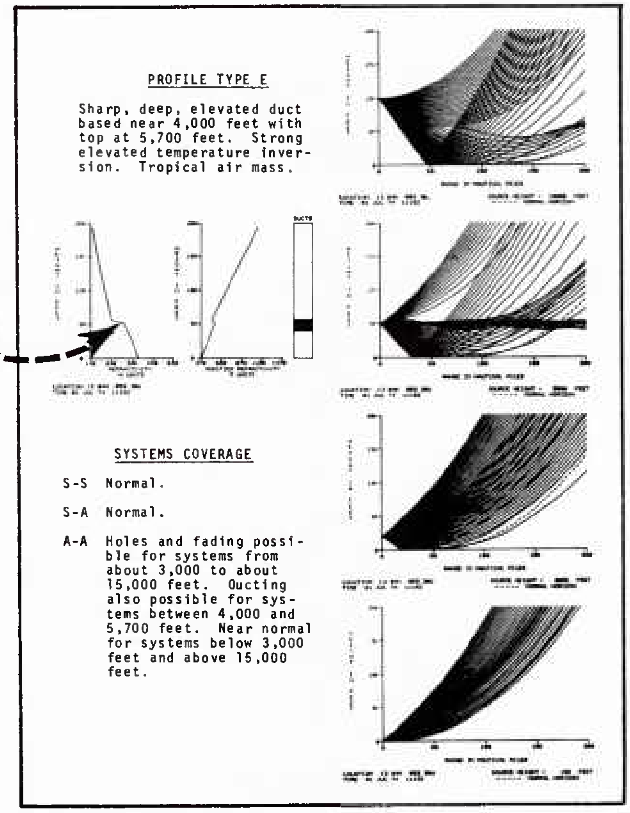
Step 2. Obtain the expected coverage conditions from the ray traces and accompanying notes for the selected profile.

Figure 2-3. Example, Technique 3.

You have (step 1):

You get (step 2):





PROFILE TYPE E

Sharp, deep, elevated duct based near 4,000 feet with top at 5,700 feet. Strong elevated temperature inversion. Tropical air mass.

SYSTEMS COVERAGE

S-S Normal.

S-A Normal.

A-A Holes and fading possible for systems from about 3,000 to about 15,000 feet. Ducting also possible for systems between 4,000 and 5,700 feet. Near normal for systems below 3,000 feet and above 15,000 feet.

## 2.6 GENERAL USE OF REG PROCEDURES

REG procedures can be applied with equal ease to both present and predicted conditions when either Technique 1 (WEAX message) or Technique 2 (facsimile chart) is used. The REG therefore can be used as a predictive tool as well as to provide guidance for immediate operations.

The meteorologist or AG should also be aware that there are additional clues that can help the REG user to relate weather to refractive conditions. For example, over the Northeast Pacific, persistent layers of low stratus clouds without rain should be regarded as an excellent indicator of ducting conditions.

## 2.7 PRIORITIES OF USE

In the operational situation, the highest level and most valid weather information available should be used as input to REG procedures. In descending order, the priorities of source information are:

(1) Actual measurements

(2) Facsimile charts; analysis or forecast

(3) WEAX messages

# 3. CONSIDERATIONS IN REG DEVELOPMENT

## 3.1 CONSTRAINTS

REG represents a continuing unique attempt to relate synoptic weather information directly to anticipated systems performance by means of a simple procedure. Because of the newness of this concept and the urgency of Fleet requirements, it was not possible during its development to meet full standards of scientific rigor. The user should be aware that the procedures presented in the REG were constrained by the following considerations:

(1) The Fleet urgently requires information about how the atmosphere affects systems performance. (The CIC Officer, for example, generally does not have time to analyze a weather chart or refractivity profile.)

(2) Large scale weather behavior generally causes the existence, extent and intensity of those anomalous refractive conditions of vital interest to Fleet units. Therefore, certain refractivity conditions can be considered characteristic of certain air mass types and large scale weather conditions. Upper air soundings taken by stations around the world tend to confirm this premise. In the REG, large scale weather patterns considered to be characteristic of each season are presented.

(3) Because nearly all upper air soundings are made from land stations, soundings from coastal and island sites provide the majority of data used to describe conditions over the open sea. For REG purposes, it was assumed that these soundings did in fact apply to the open sea.

(4) No thorough objective study has yet related refractive profile types to air mass and/or synoptic patterns. REG profiles were selected according to air mass properties, regardless of geographical location. Although profile letters assigned to synoptic features are only generally valid, they are based upon similar situations and sound meteorological analysis.

(5) Refractive profiles and ray traces were calculated by NELC on IREPS. Ray trace techniques provide a qualitative picture of propagation conditions independent of specific systems considerations such as frequency, power, detection range, etc. In the absence of coverage diagrams for specific radar systems (which are under development in IREPS), these calculations are considered suitable for approximate operational evaluation of radar coverage. Rays depicted generally range from between +1 degree to -1 degree from the horizontal.

(6) It was assumed that small size irregularities in weather systems could be ignored for ray trace calculations and profile selection. REG users should be aware that

changes in profile type at a particular location are due more to the steady movement of weather systems than to changes in their shape or characteristics.

## 3.2 FUTURE OUTLOOK

Because of these constraints as well as the irregularities of the atmosphere itself, it is obviously not possible to develop predictions and conclusions that are absolutely valid in all situations. In some areas and synoptic patterns, they may not verify well. It is believed, however, that the REG approach addresses the essential considerations and expected systems coverage, and that it provides valuable new guidance in a critical area where little information previously existed.

As with any new concept, continuing improvements and refinements can be expected as procedures are modified and newer, more complete data become available. This initial guidebook should enable the system operator and operational commander to make useful tactical planning decisions that optimize use of all systems resources.

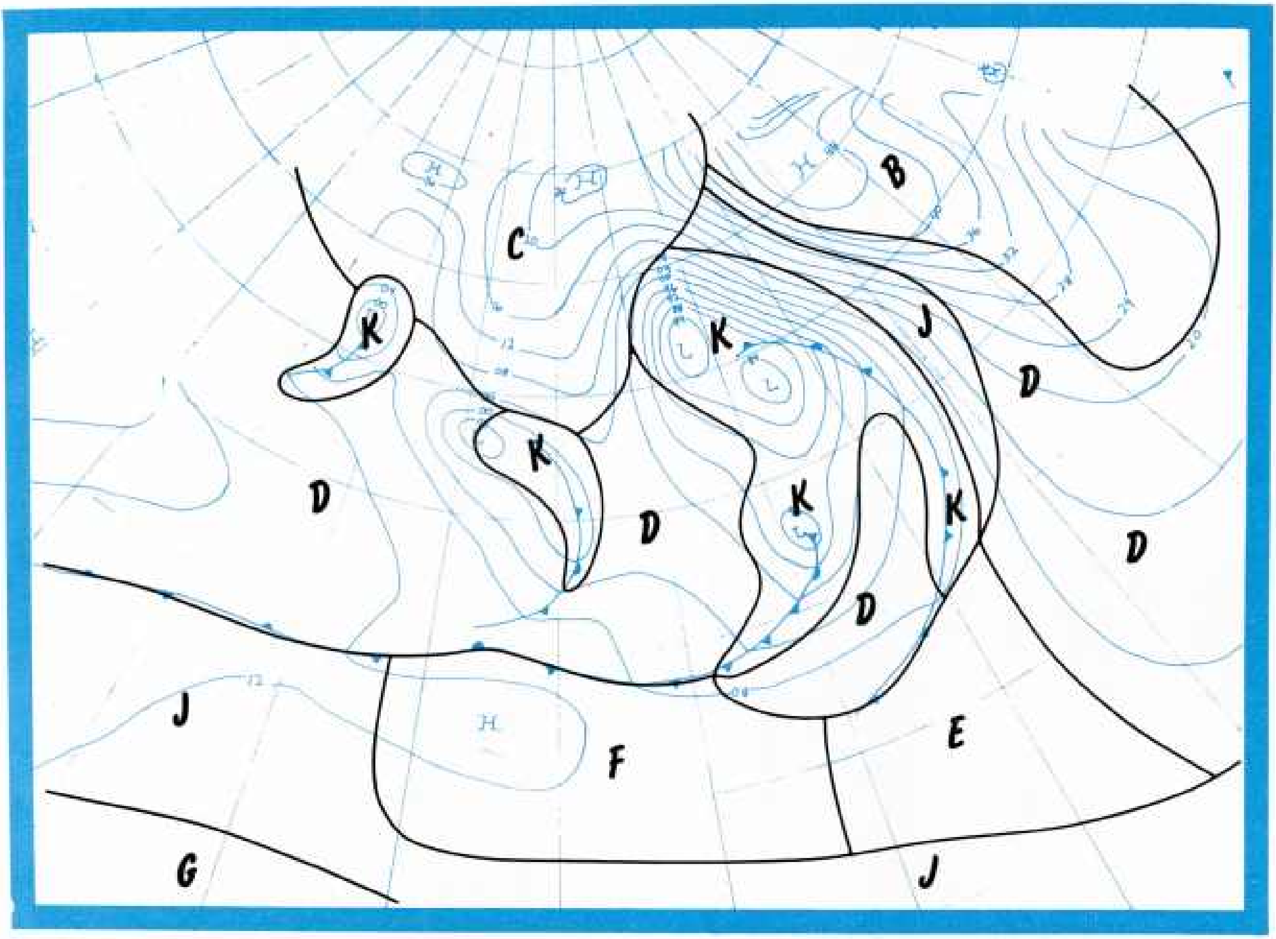
To keep pace with the Navy's increasing use of environmental satellite technology, REG capabilities will be expanded in the near future by the inclusion of weather satellite photographs. These pictures of actual cloud

patterns associated with oceanic weather systems will be related to expected sensor systems coverage in much the same way that facsimile charts are used in the present version of the REG.

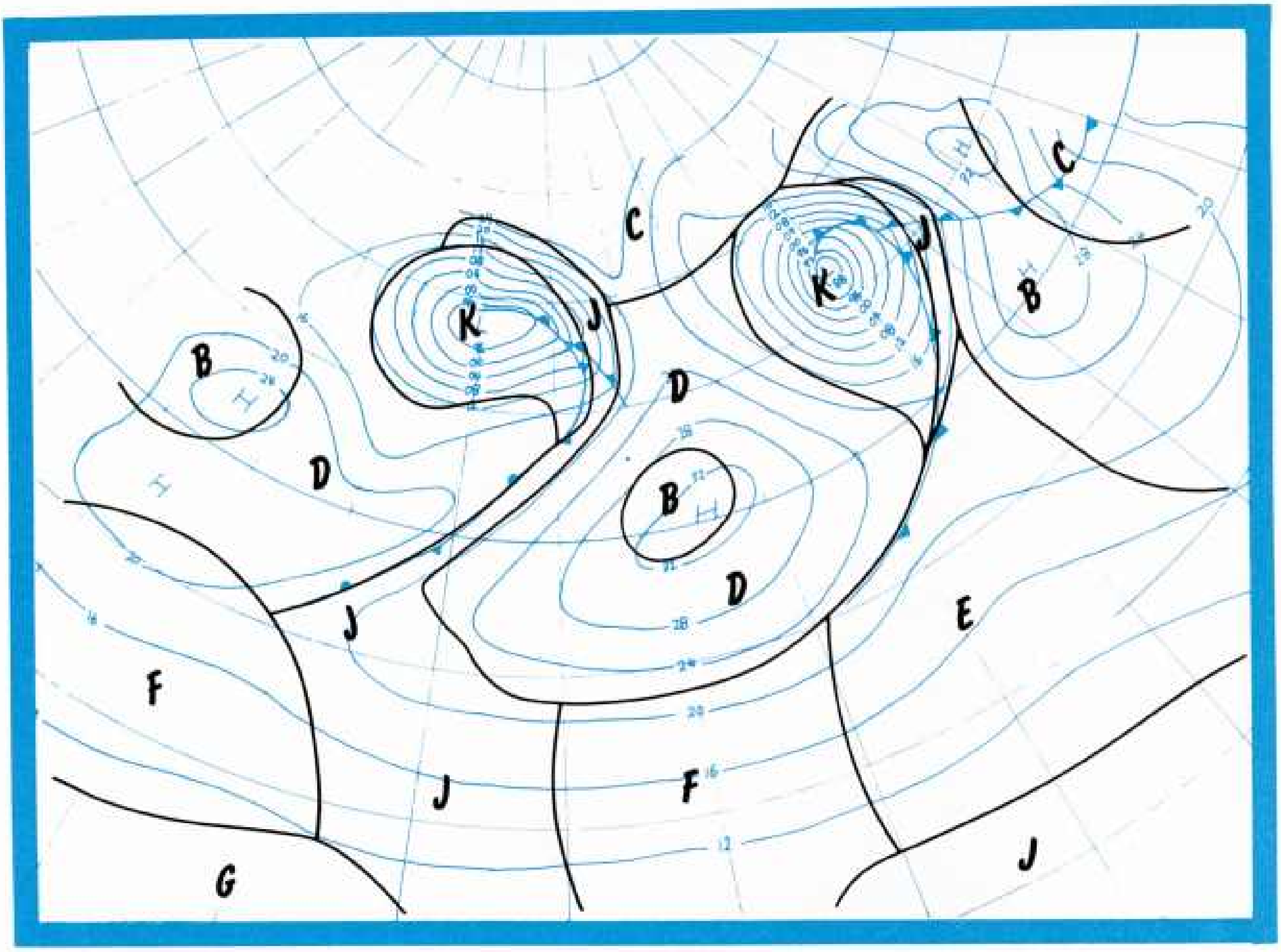
# 4. SYNOPTIC CHARTS

The charts presented in this section depict weather patterns that are typical for the seasons and ocean areas specified. The superimposed letters on each chart indicate the REG profiles in Section 5 that apply to the various areas and weather features pictured.

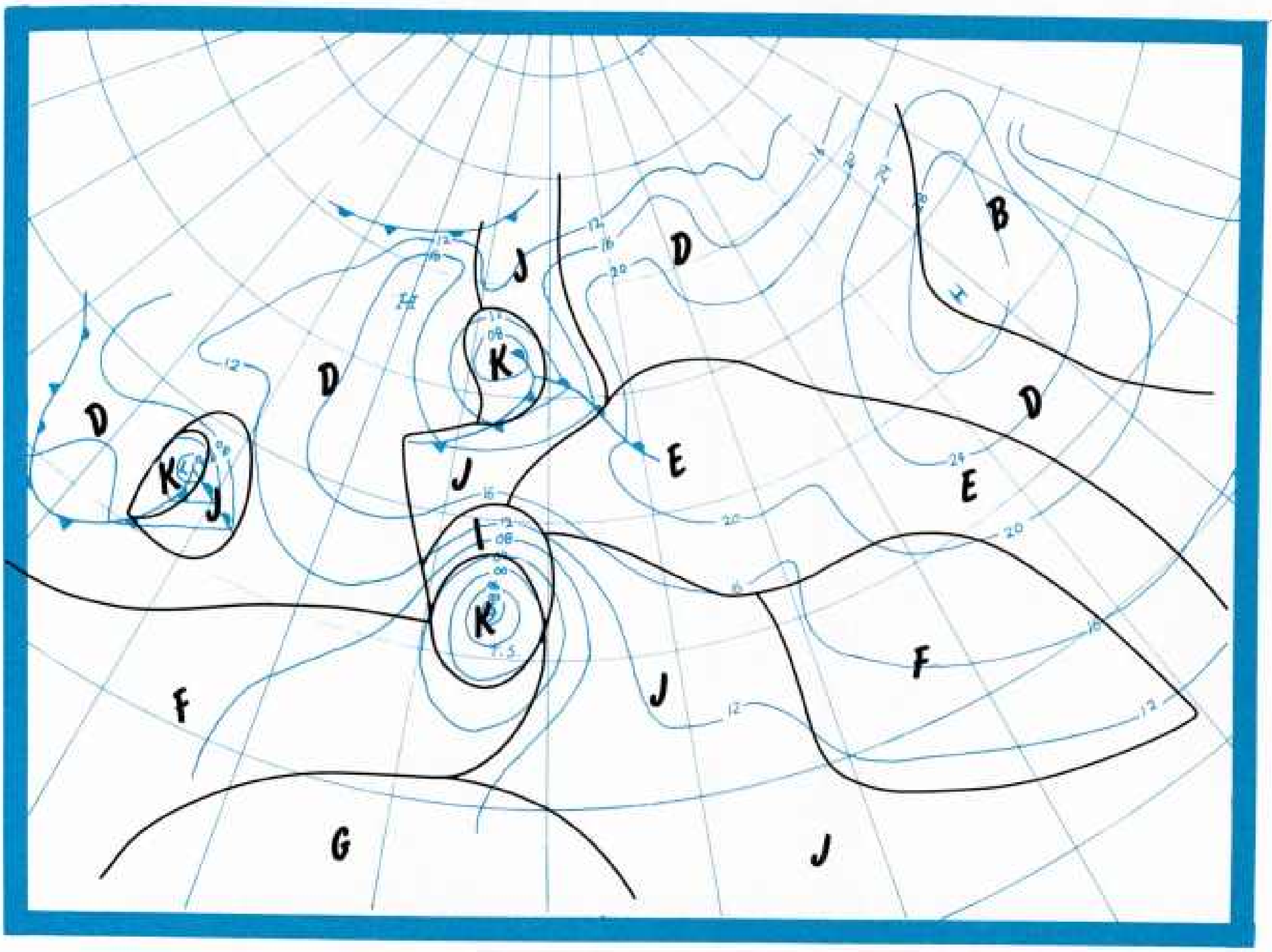
It will be seen that these profile letters exhibit certain sequences for certain weather features. For instance, air masses in storms, fronts and equatorial zones generally are lacking in refractive layerings and are characterized in the REG by profile K. Air masses within strong high pressure cells generally exhibit ducts which are low near the center (profile B) and higher away from the center (profiles C, D, etc.). Tropical regions on either side of the equator are often characterized by REG profiles E, F, G, H and J, depending on nearness to the equatorial zone.



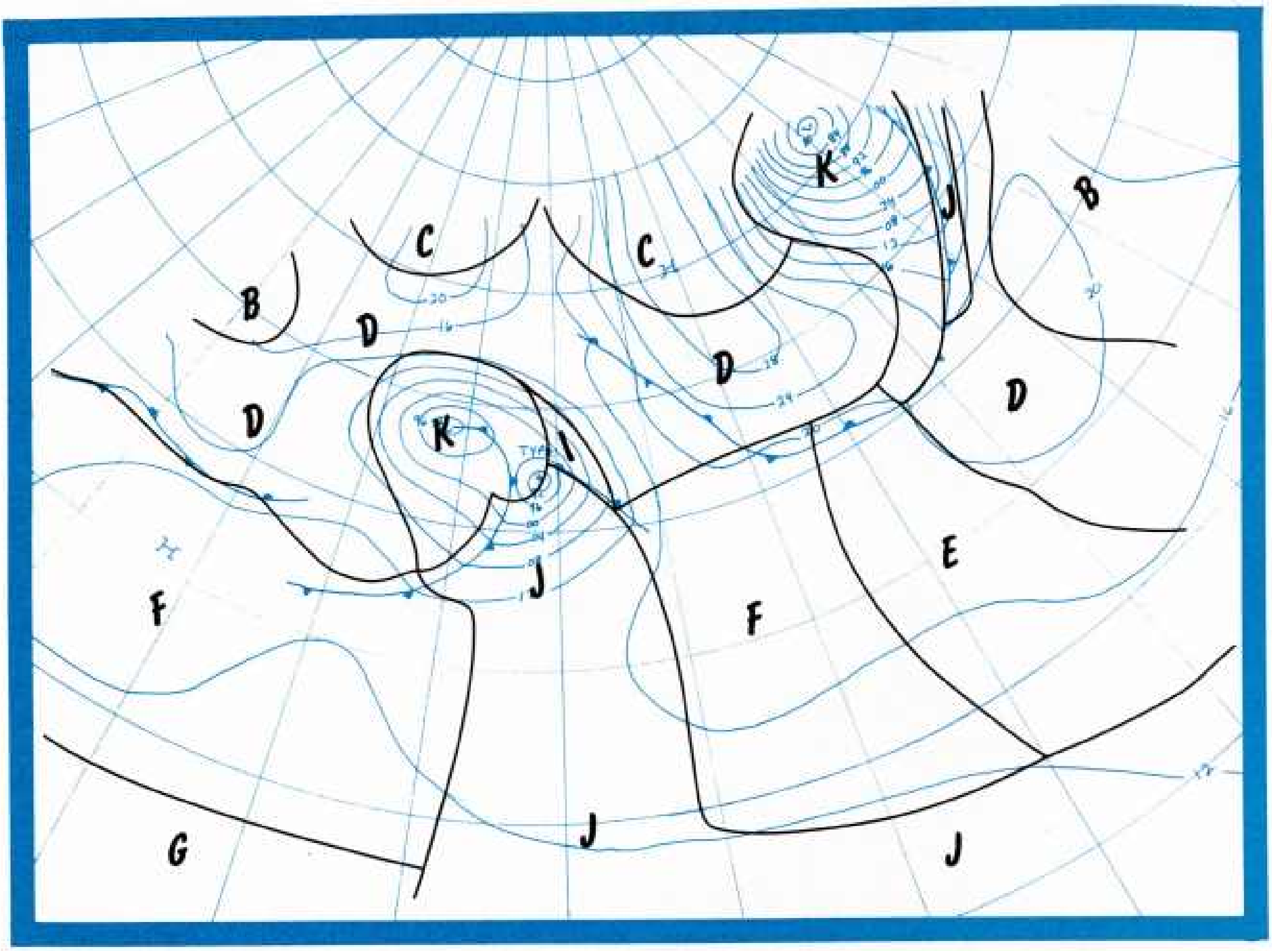

North Pacific, Winter. Strong high pressure to north and east, deep low and frontal systems in central Pacific.



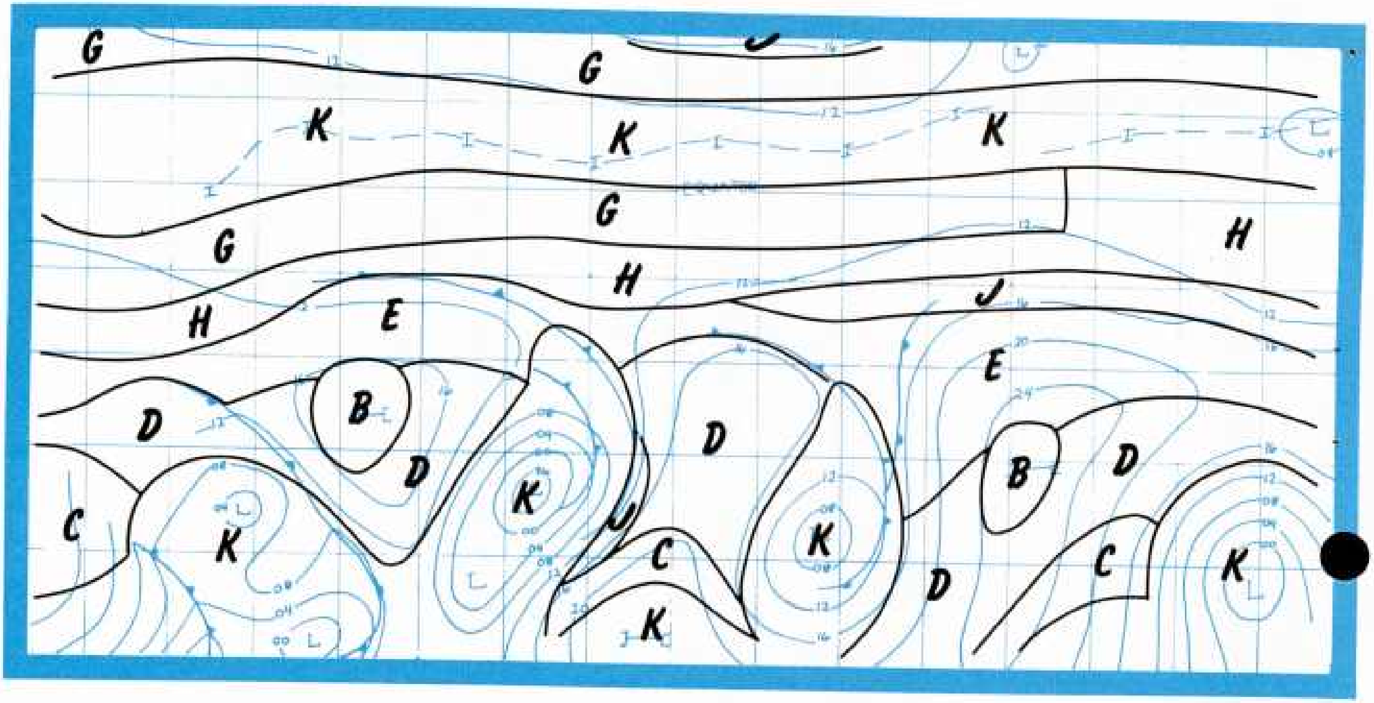

<u>North Pacific, Spring</u>. Pacific High well defined as part of high pressure belt in southern and central regions. Strong lows with well defined fronts trail from the north.



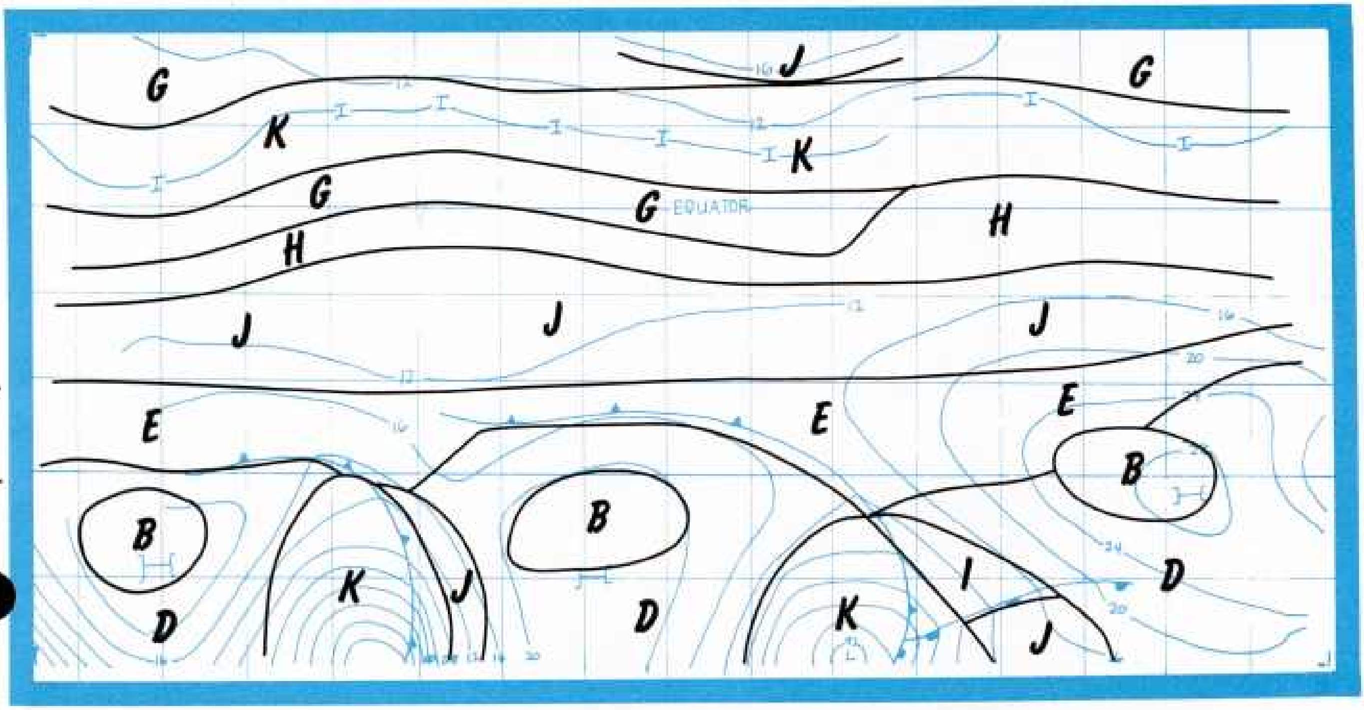

North Pacific, Summer. Pacific High dominant over eastern Pacific, western Pacific influenced by tropical storms to south and frontal activity far to north.



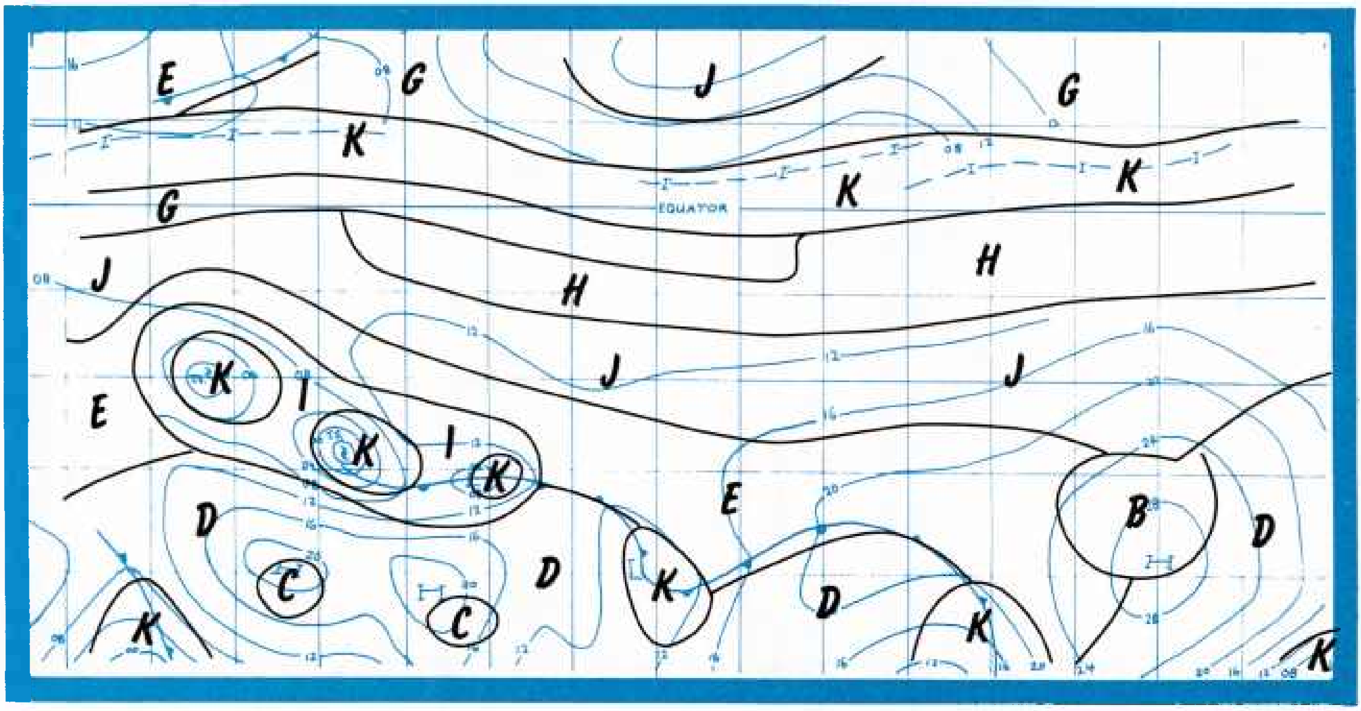

North Pacific, Fall. Typhoon and deep low west central Pacific, cold high to the north. Deep low to northeast.




South Pacific, Winter. Chain of well-defined lows and frontal systems separated by strong highs. Tropical air covers low latitudes.

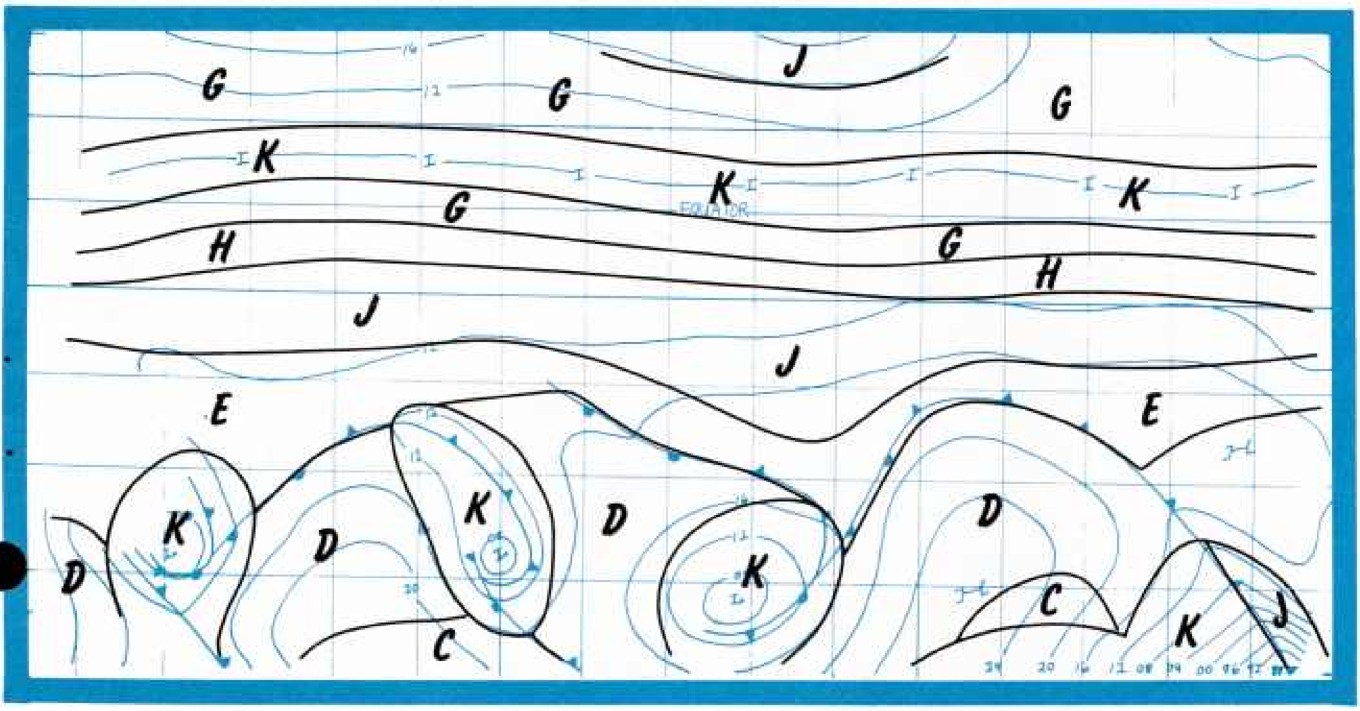



South Pacific, Spring. Large high cells separated by intense lows and frontal systems traversing southern areas.

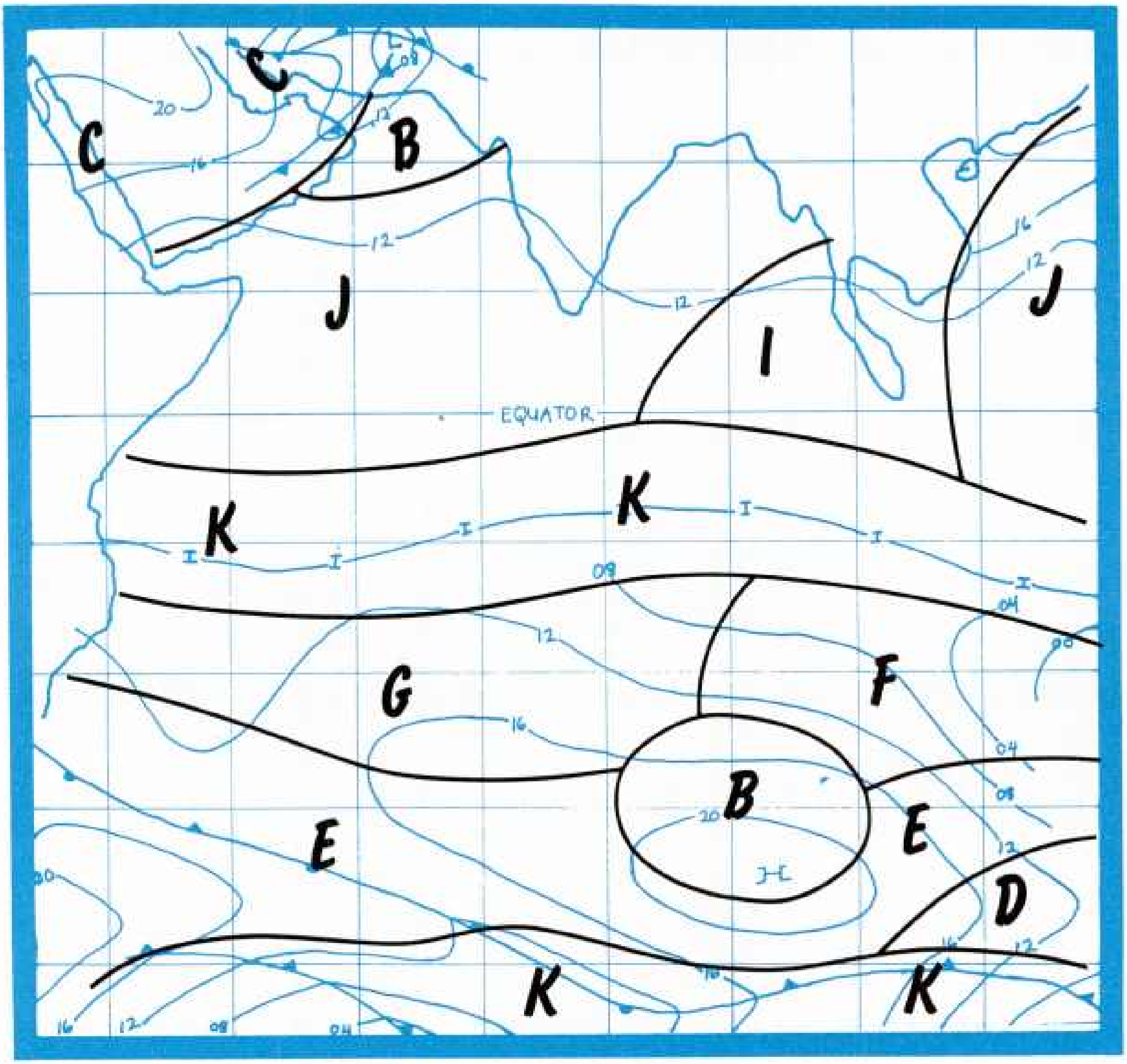



South Pacific, Summer. Chain of tropical storms and disturbances traverse western areas with strong high over east and southern regions.

South Pacific, Fall

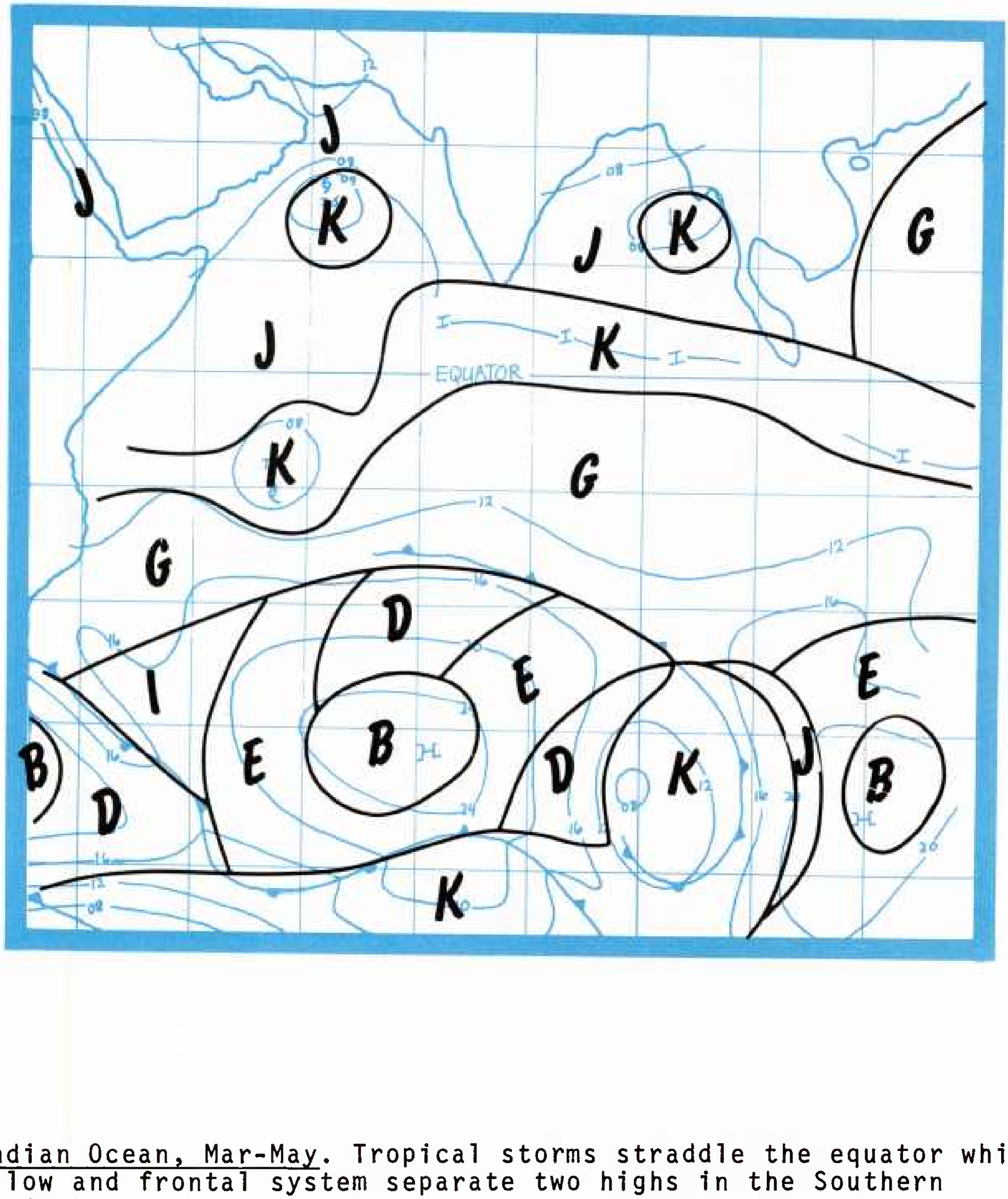



South Pacific, Fall. Series of lows and frontal systems traversing southern areas separated by high pressure cells.

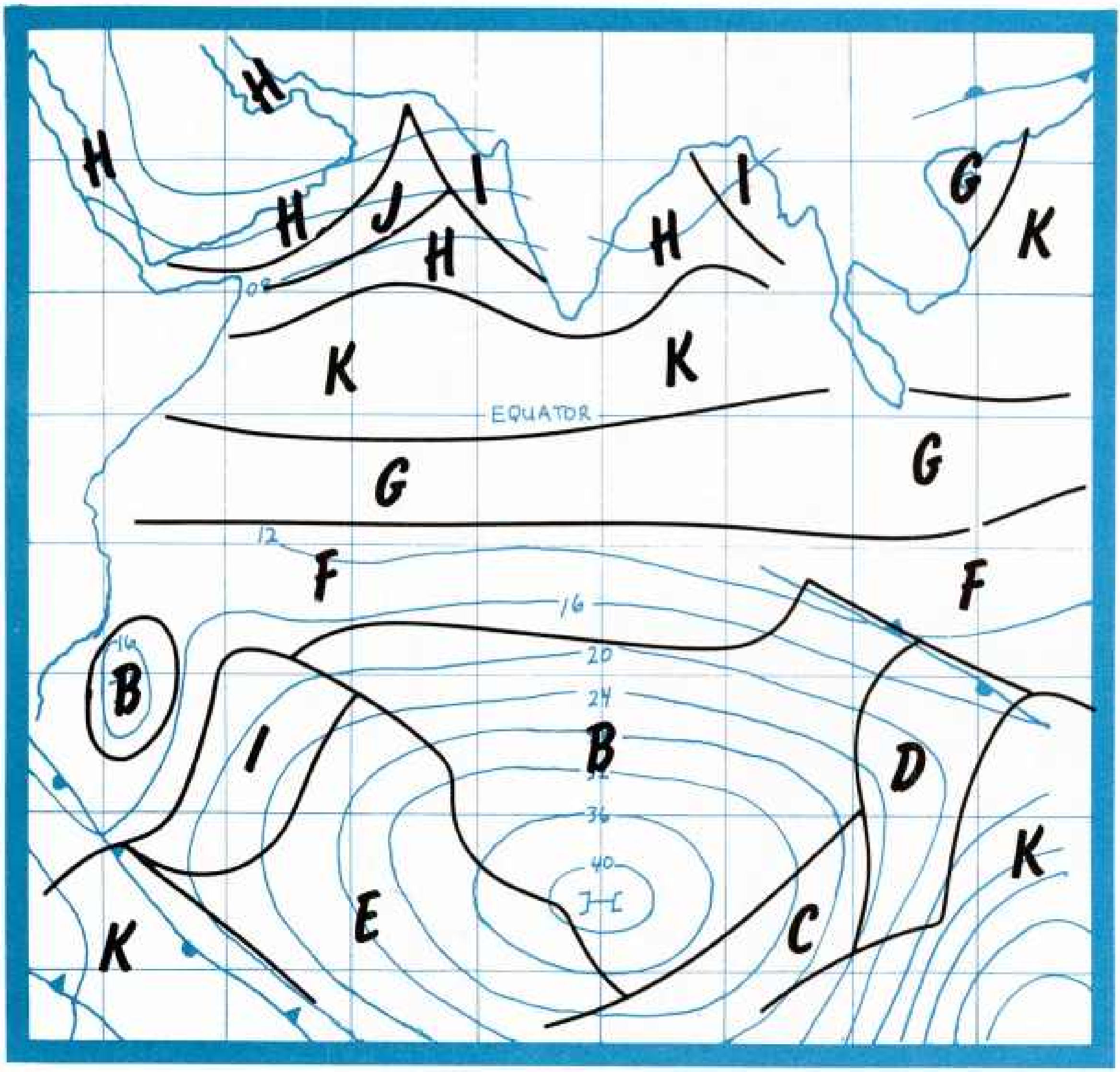



Indian Ocean, Dec-Feb. Well defined low and frontal system in northwest near Gulf of Oman, otherwise flat pressure field in Northern Hemisphere areas. Broad high pressure belt covers most of the Southern Hemisphere area.

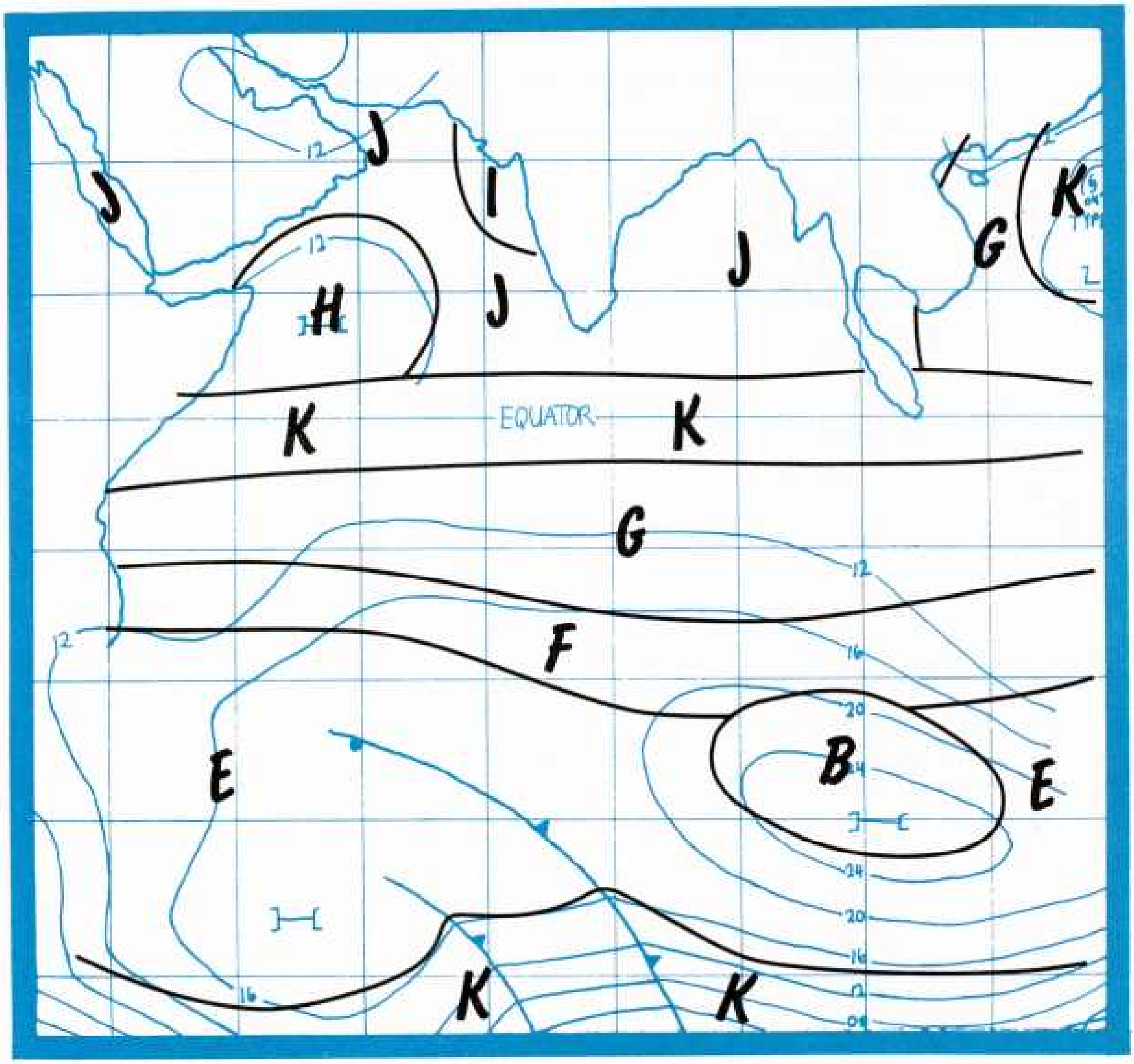
Indian Ocean, Mar-May



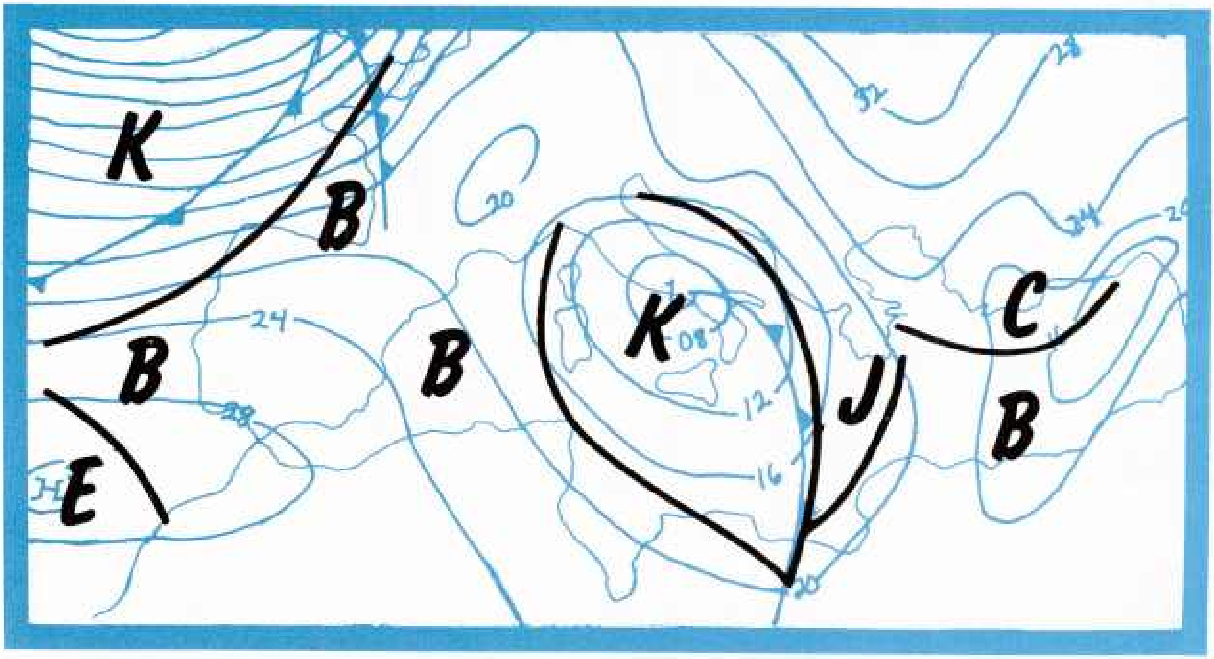

Indian Ocean, Mar-May. Tropical storms straddle the equator while a low and frontal system separate two highs in the Southern Hemisphere area.




Indian Ocean, Jun-Aug. Northern Hemisphere area marked by wet monsoonal circulation while a strong high prevails in Southern Hemisphere areas.

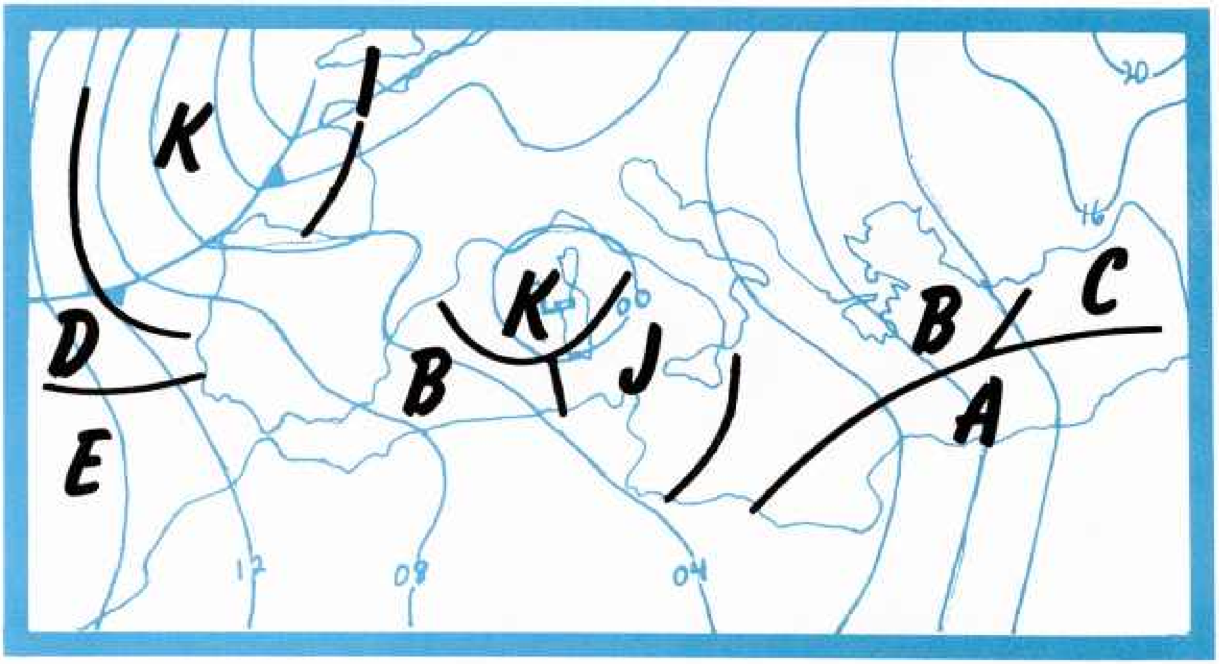



Indian Ocean, Sep-Nov. Flat pressure field prevails in Northern Hemisphere areas except for typhoon in extreme northeast section. High pressure prevails over Southern Hemisphere areas with few cold fronts moving from west to east.

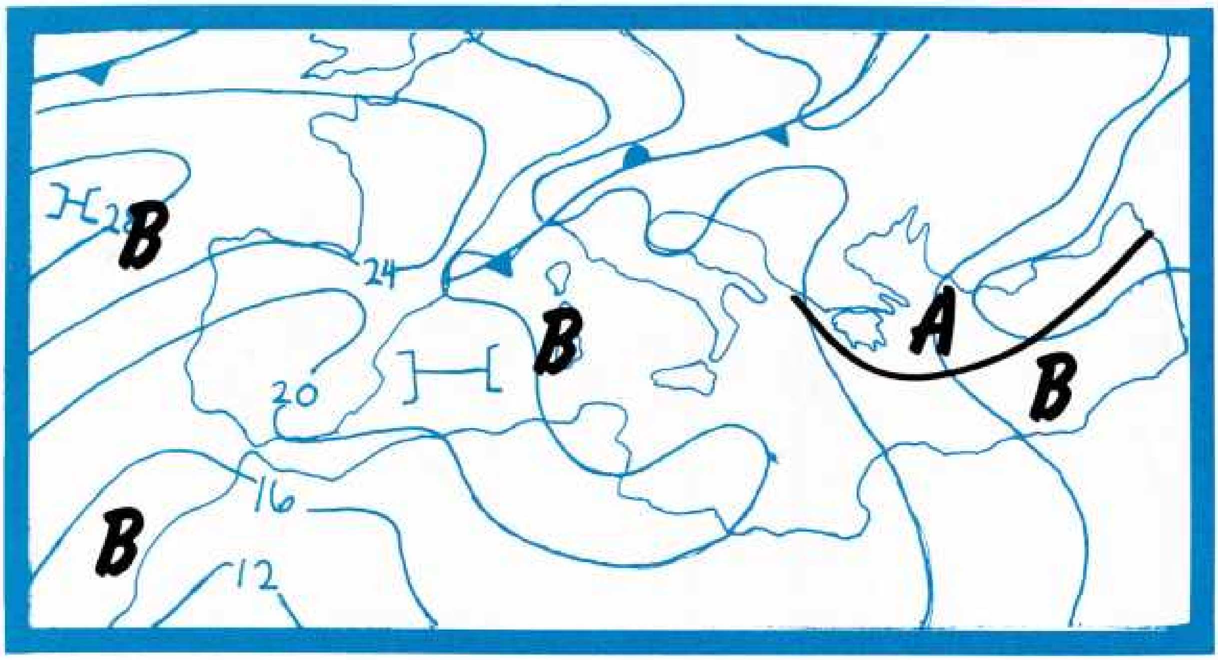



Mediterranean Sea, Winter. Deep low trailing frontal system in central Mediterranean with higher pressure at west and east ends.

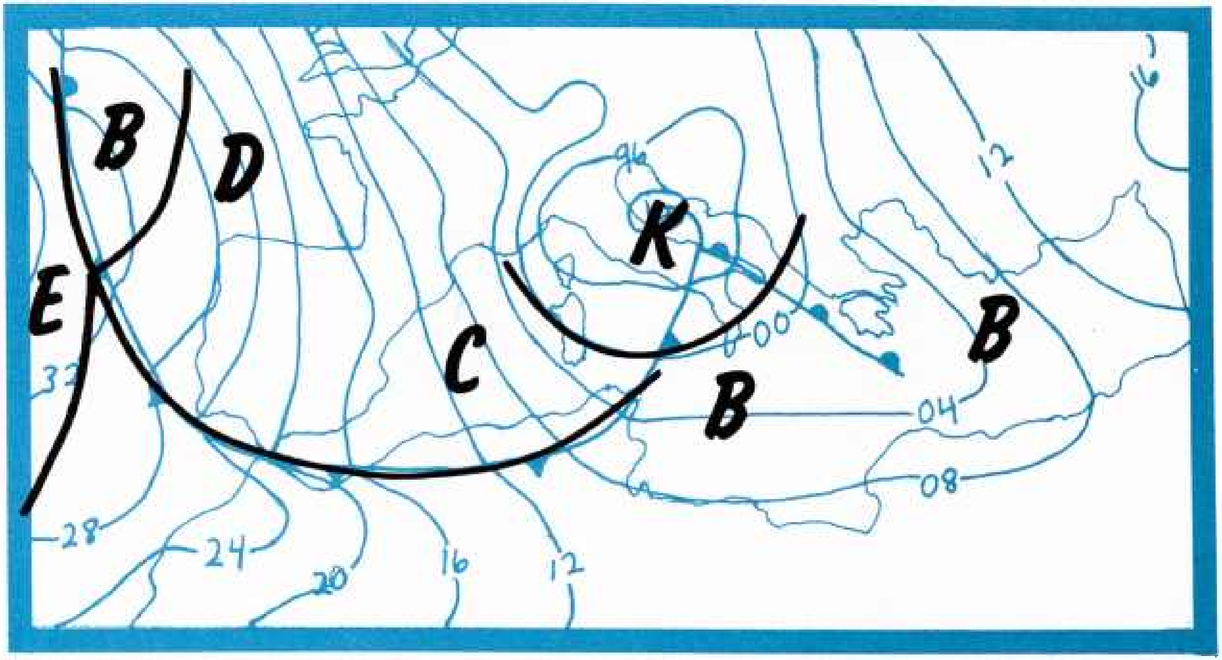
Mediterranean Sea, Spring




<u>Mediterranean Sea, Spring</u>. Flat low pressure covers central Mediterranean. High pressure ridges in from the Atlantic.

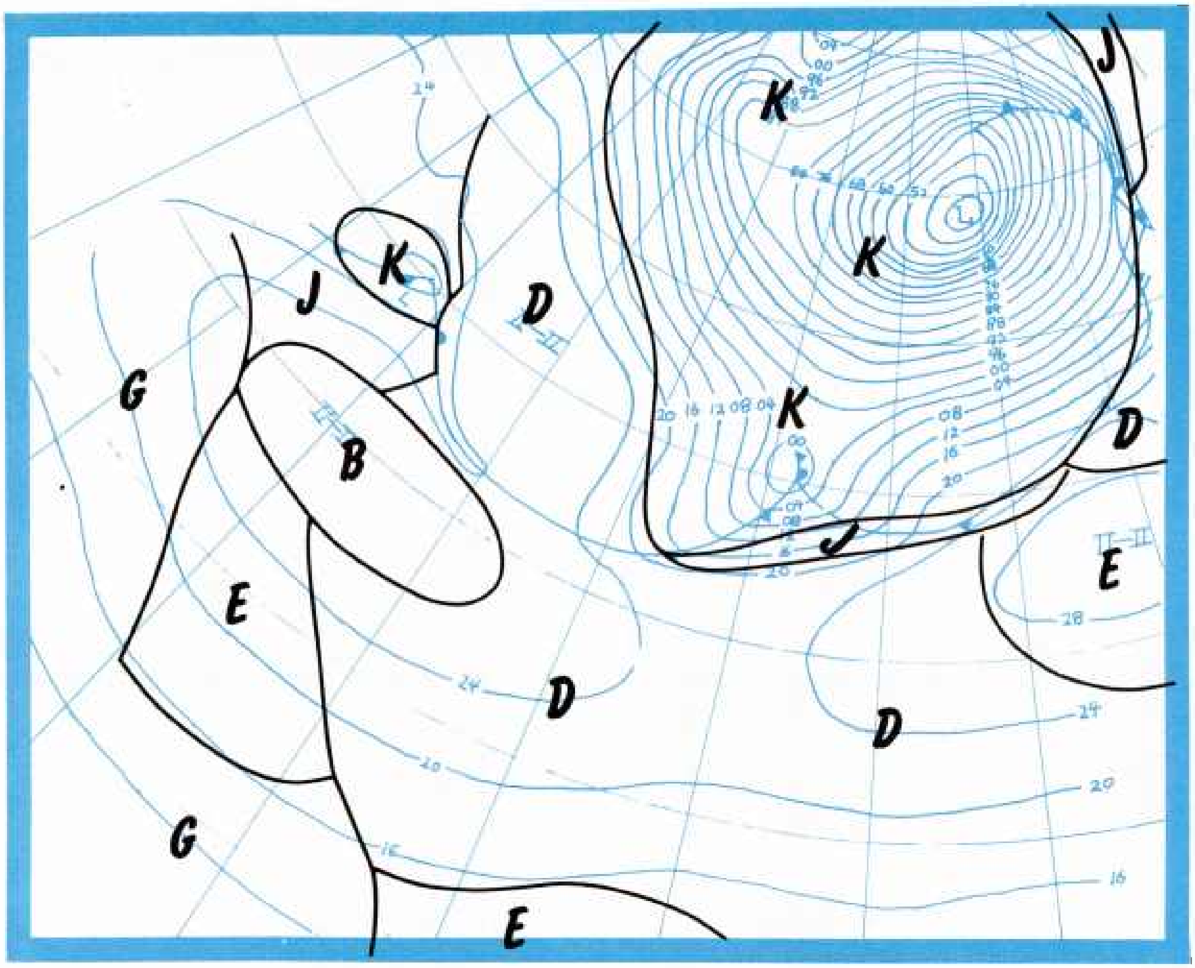



Mediterranean Sea, Summer. High pressure noses into western area from Atlantic with lower pressure covering the east end.

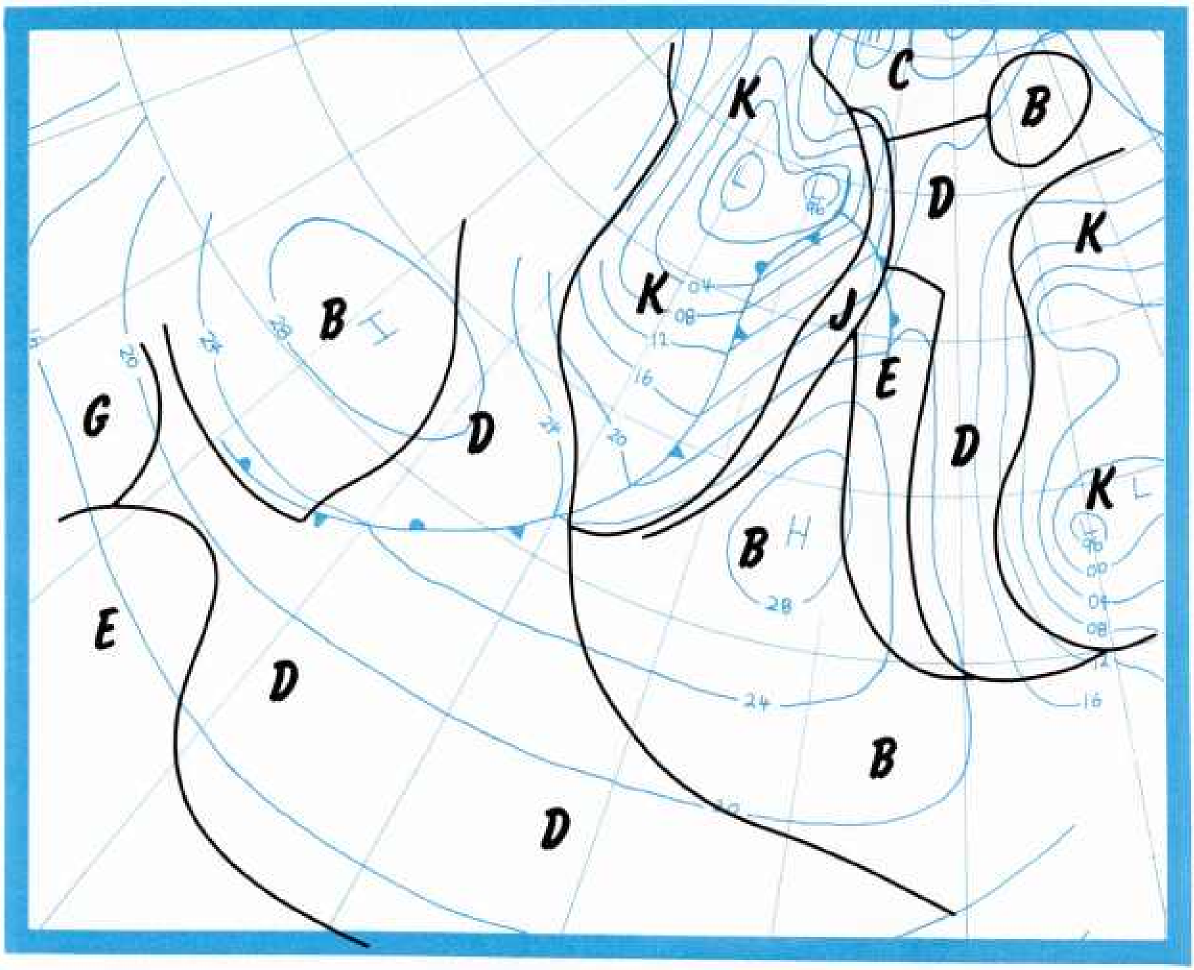



Mediterranean Sea, Fall. Strong high ridging in from the Atlantic with offshore flow over western Mediterranean. A front trails from a low over north central Mediterranean coast.

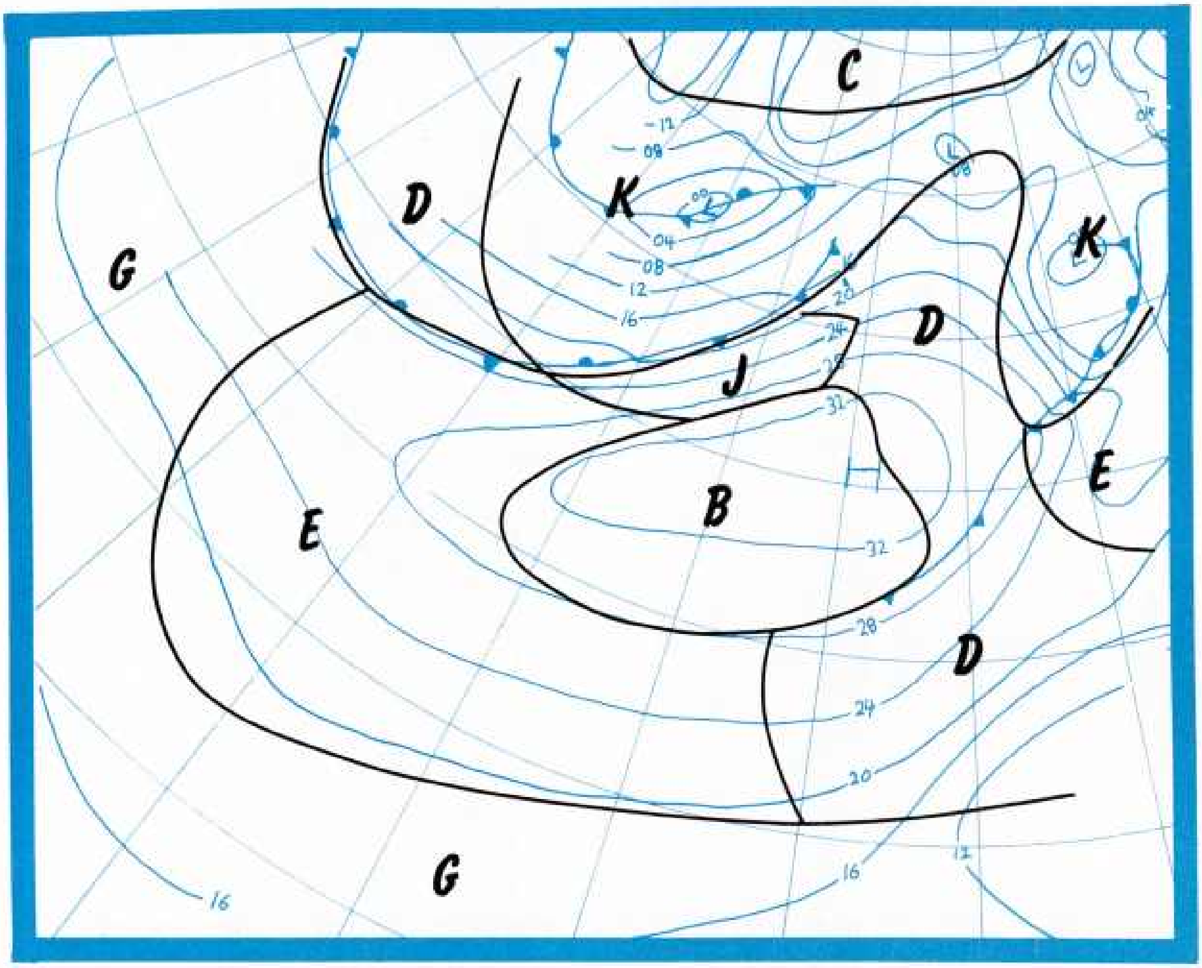
North Atlantic, Winter



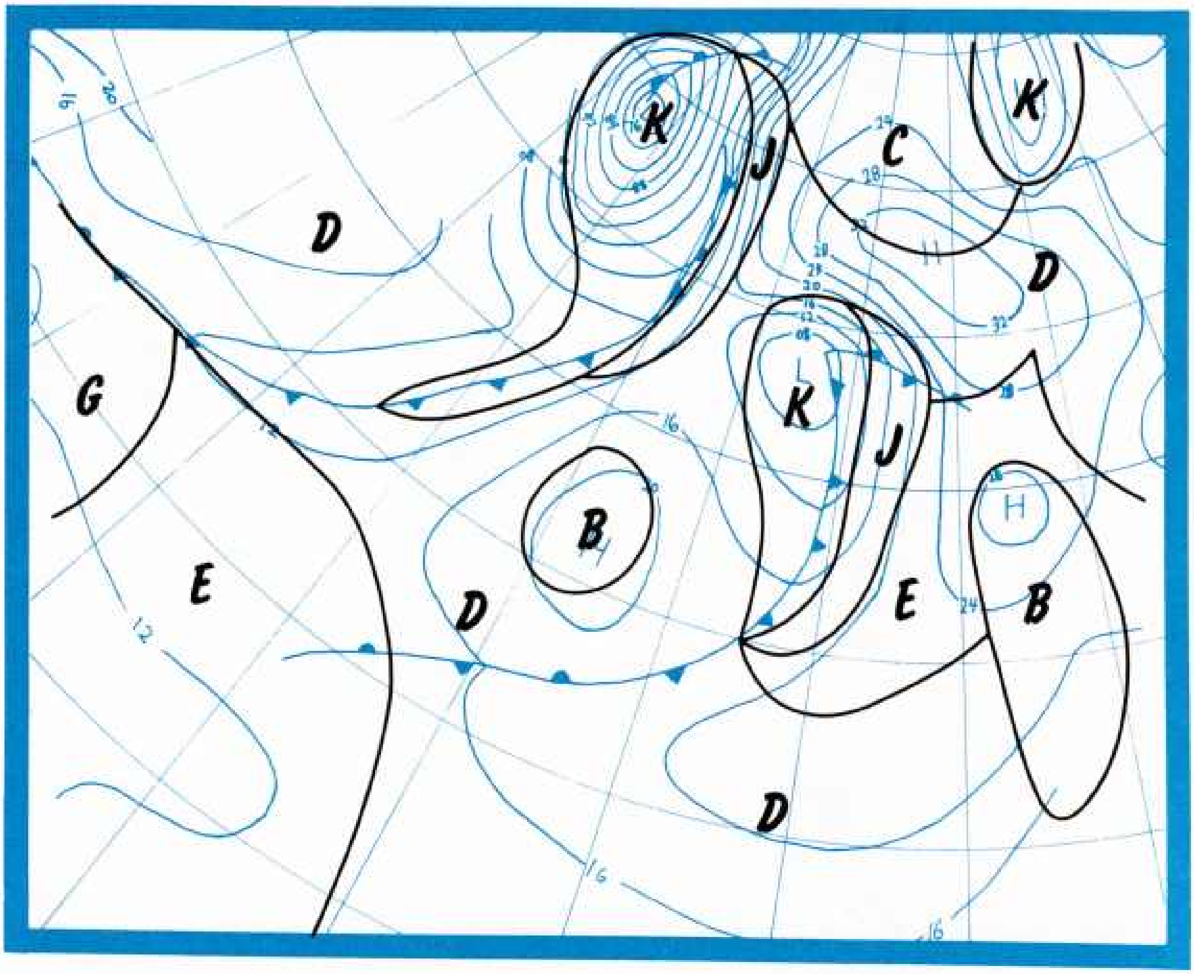

North Atlantic, Winter. Very deep lows cover northeast and north central Atlantic; high pressure belt covers southern half.



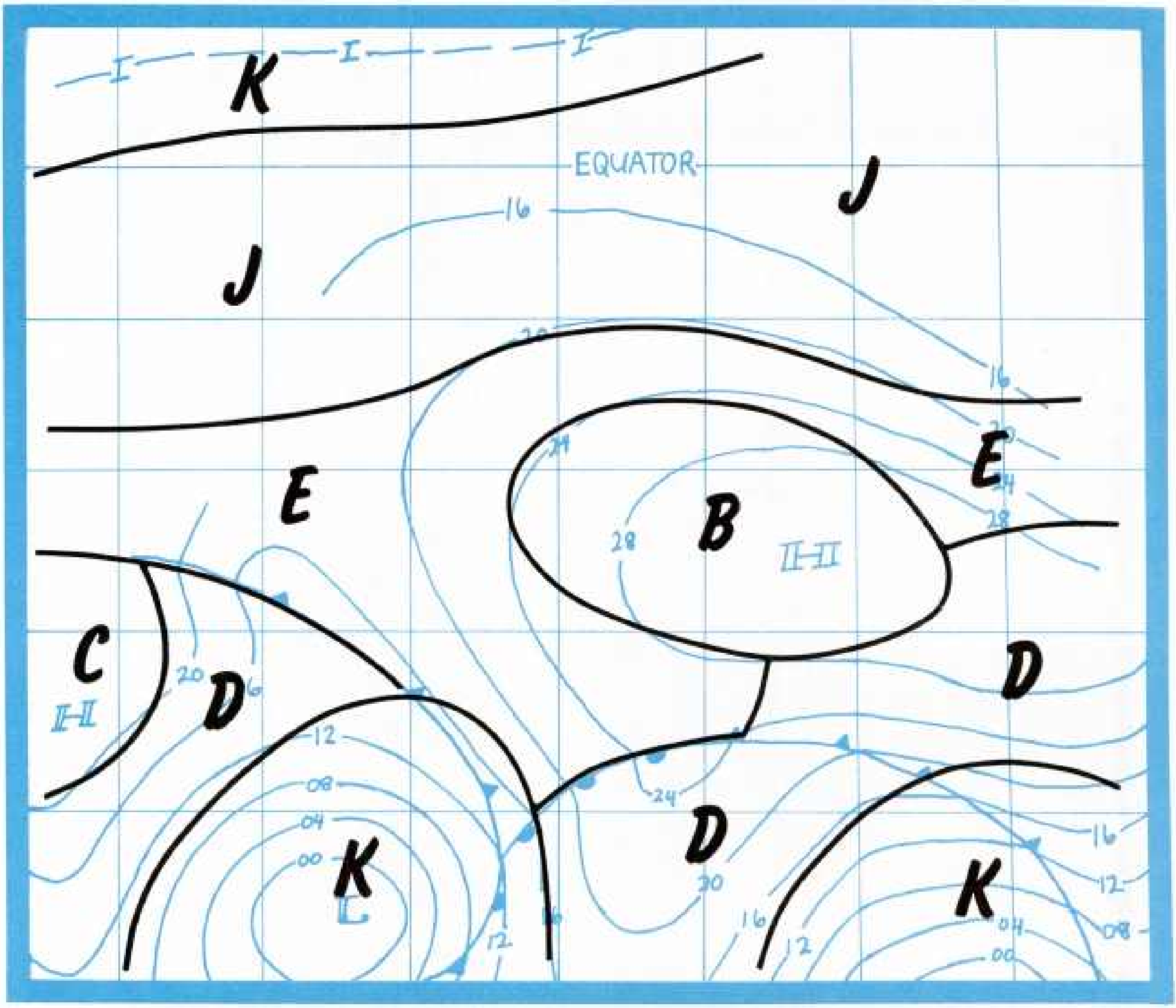

<u>North Atlantic, Spring</u>. High pressure prevails over most of the Atlantic with deep lows to north and extreme east. Front divides high into two cells.



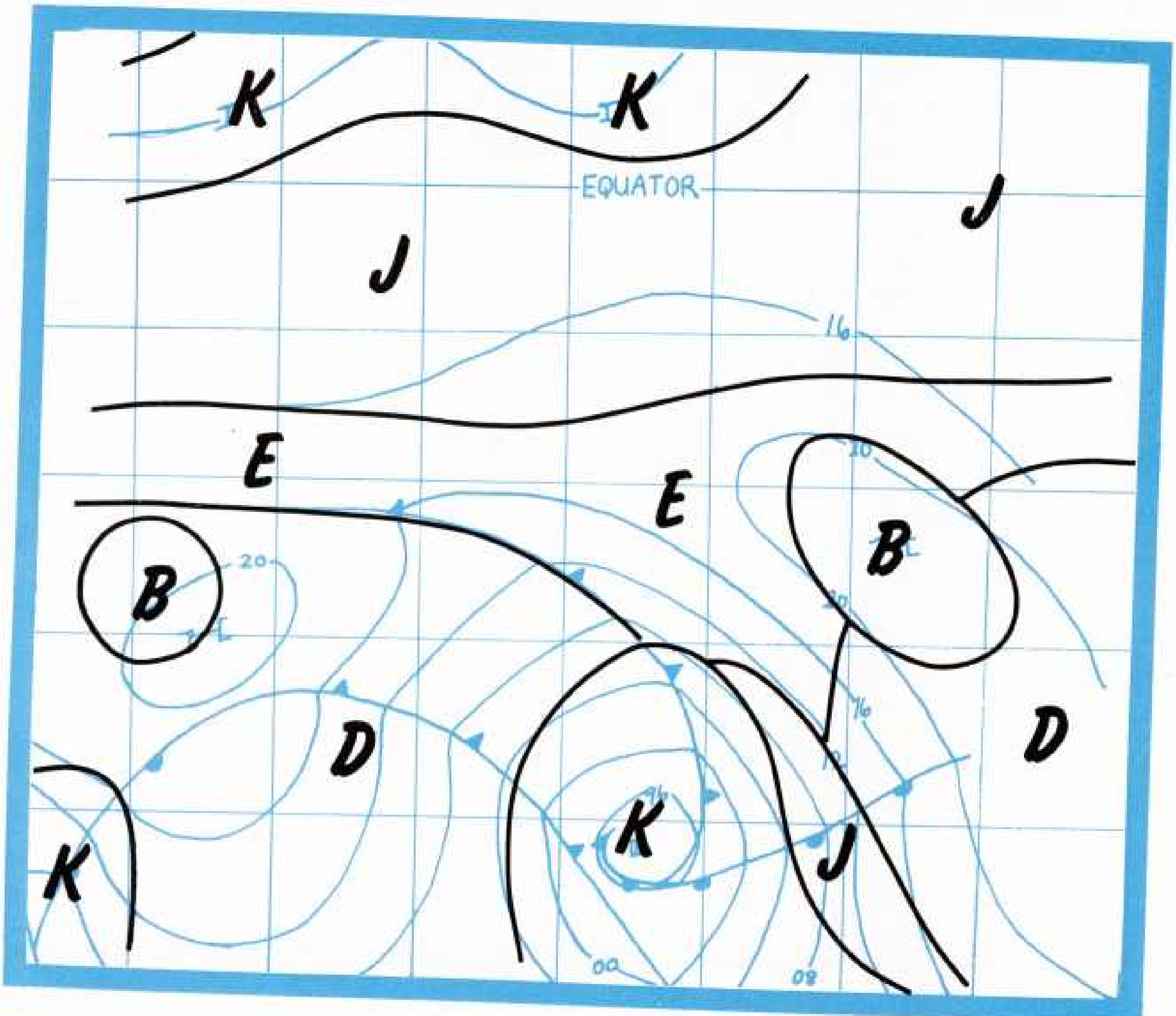

North Atlantic, Summer. High pressure covers most of the Atlantic; weak frontal systems traverse northern areas.



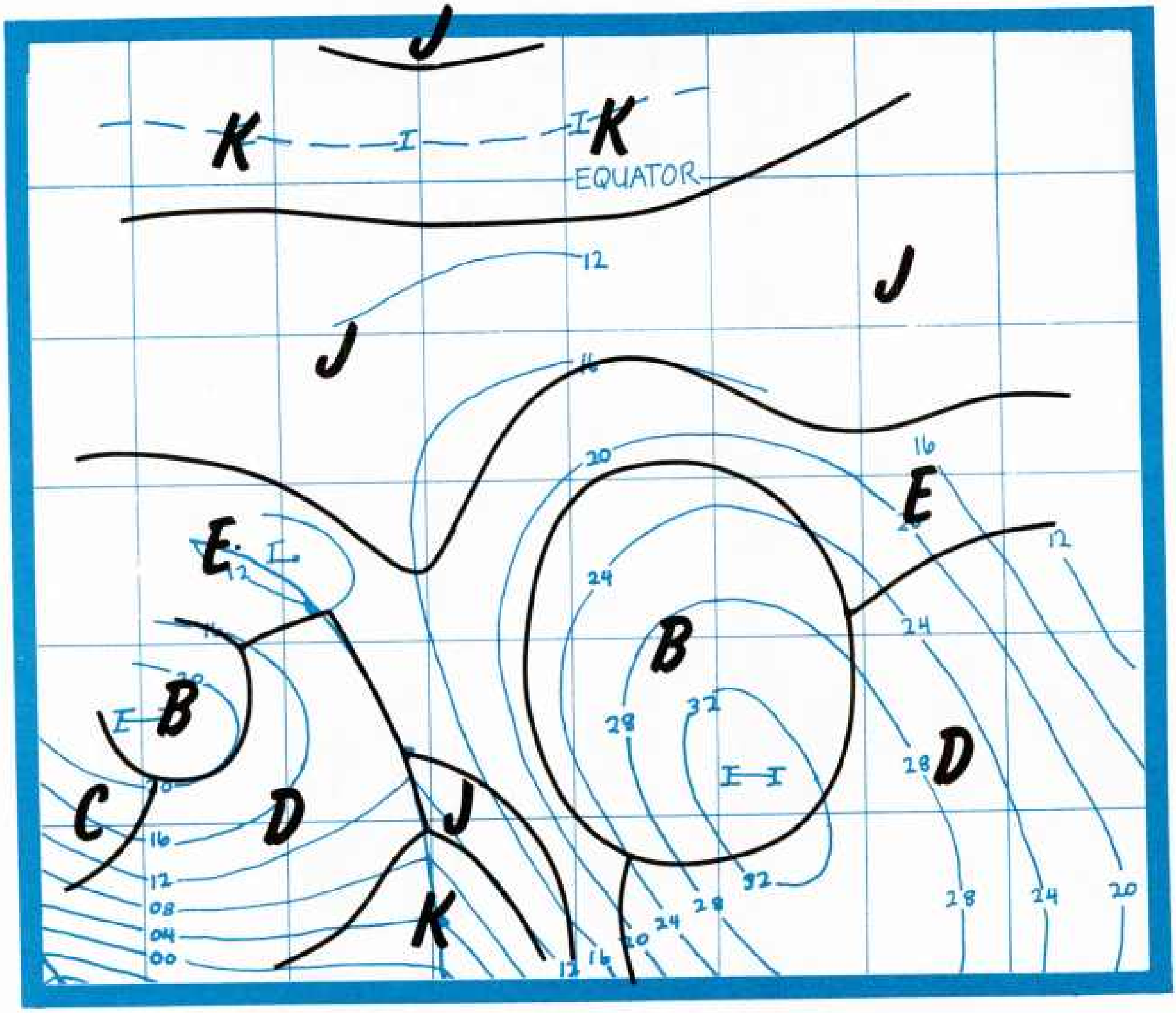

<u>North Atlantic, Fall</u>. Strong high to east and south. Deep lows and frontal systems traversing the north and west.



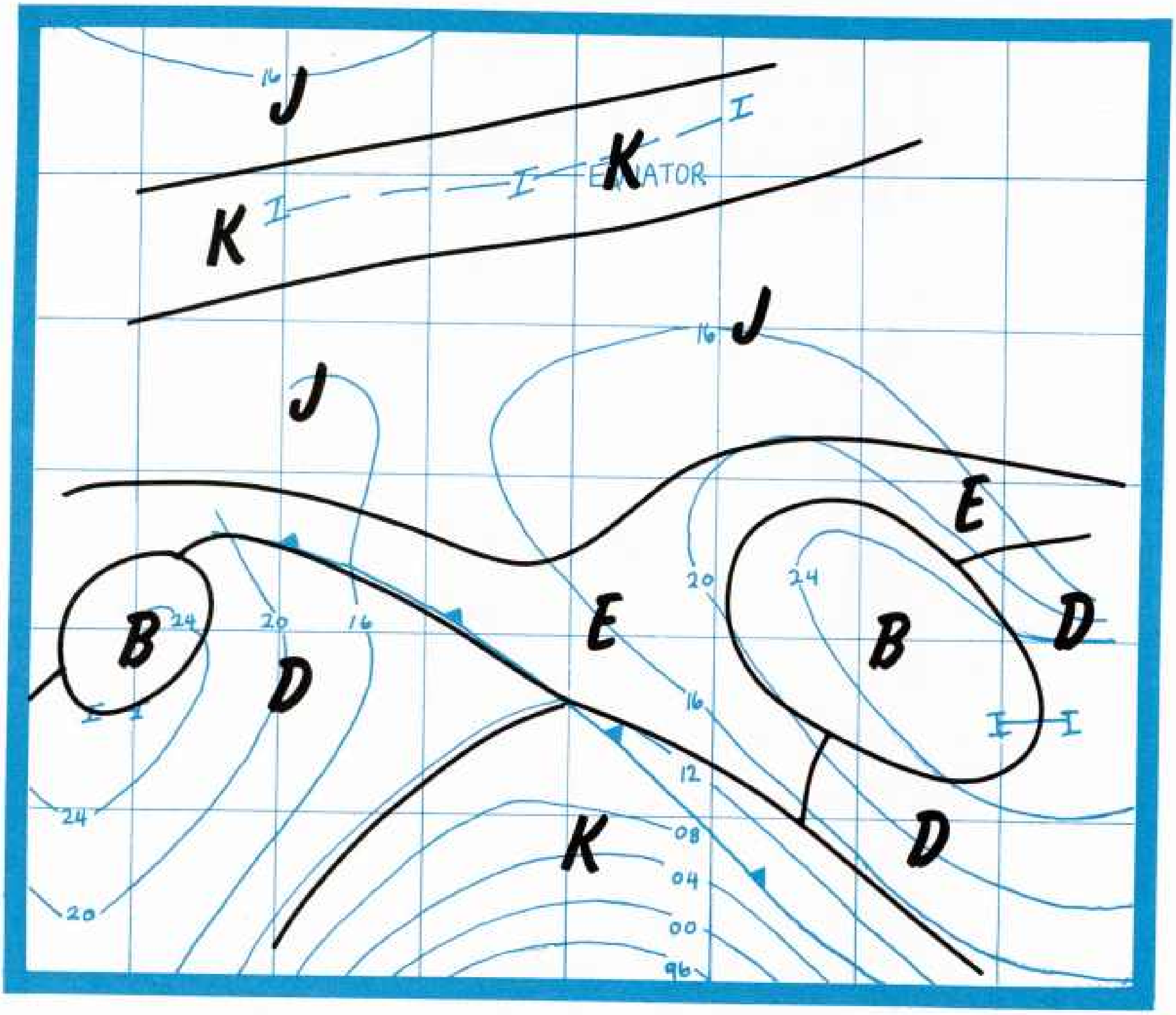

South Atlantic, Winter. Deep low over southwest area with large high cell over east and central South Atlantic.



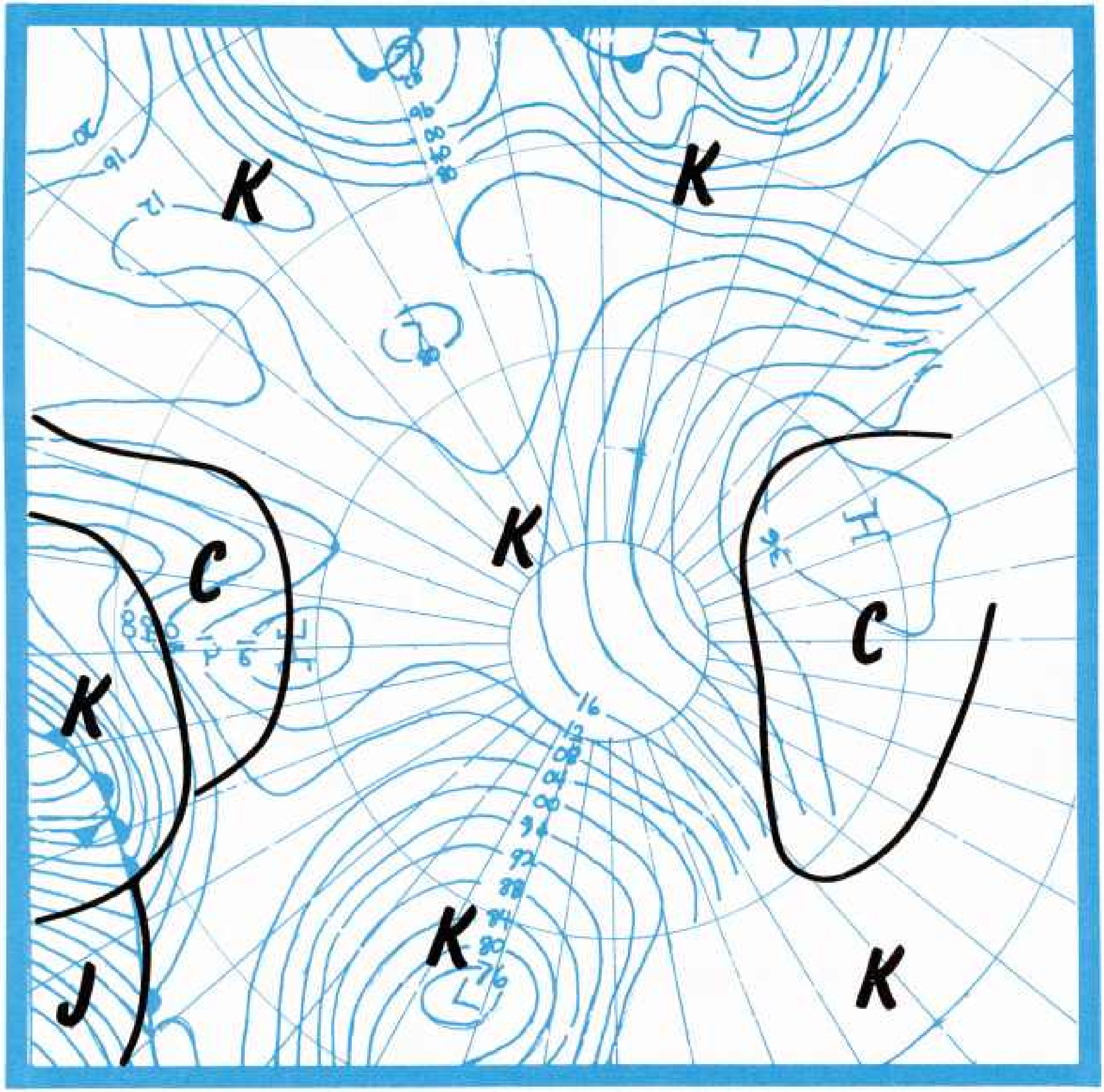

South Atlantic, Spring. Deep low in south central area with complex frontal system. High cells prevail to east and west.



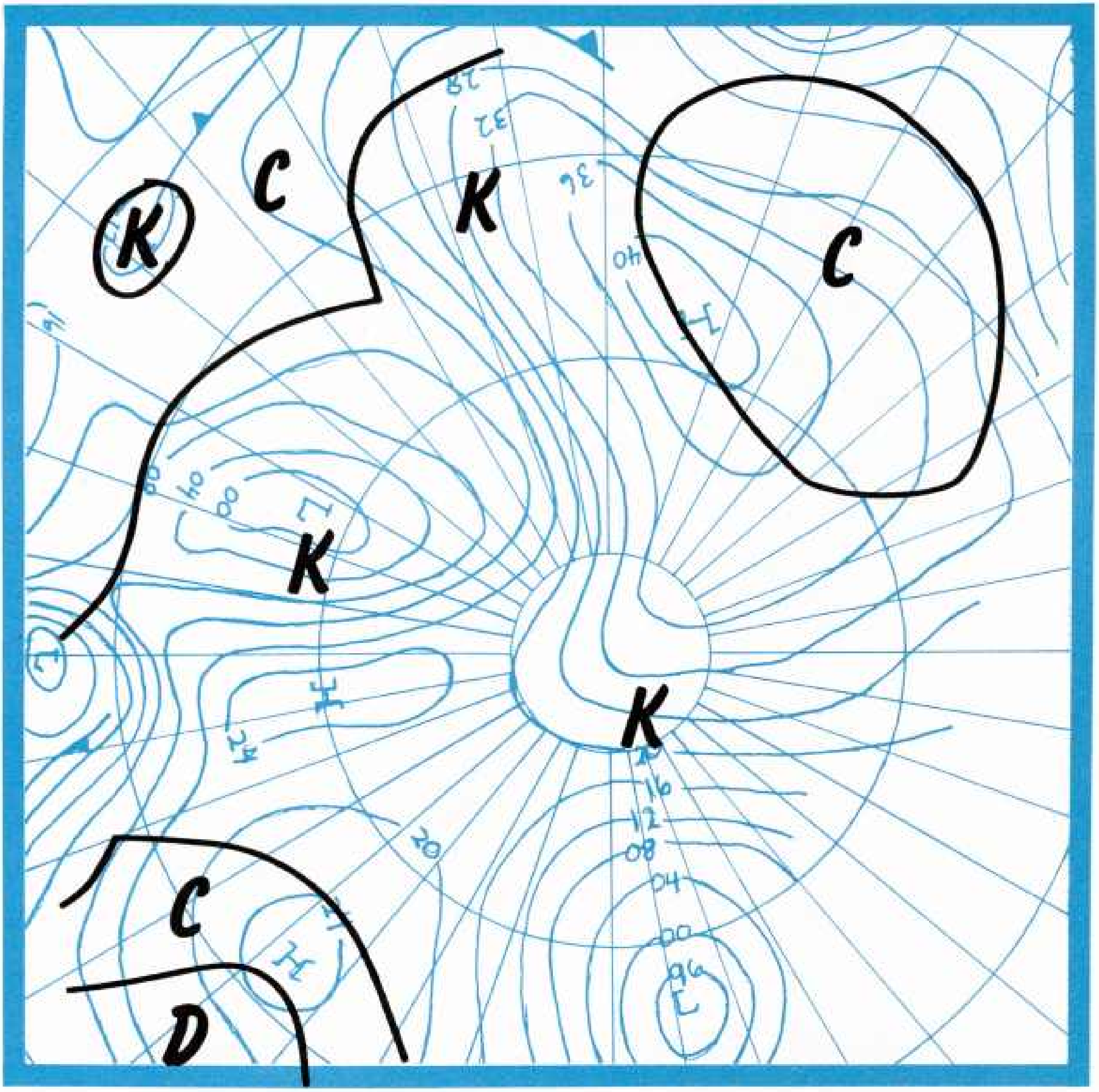

South Atlantic, Summer. Two strong high cells divided by weak frontal system.



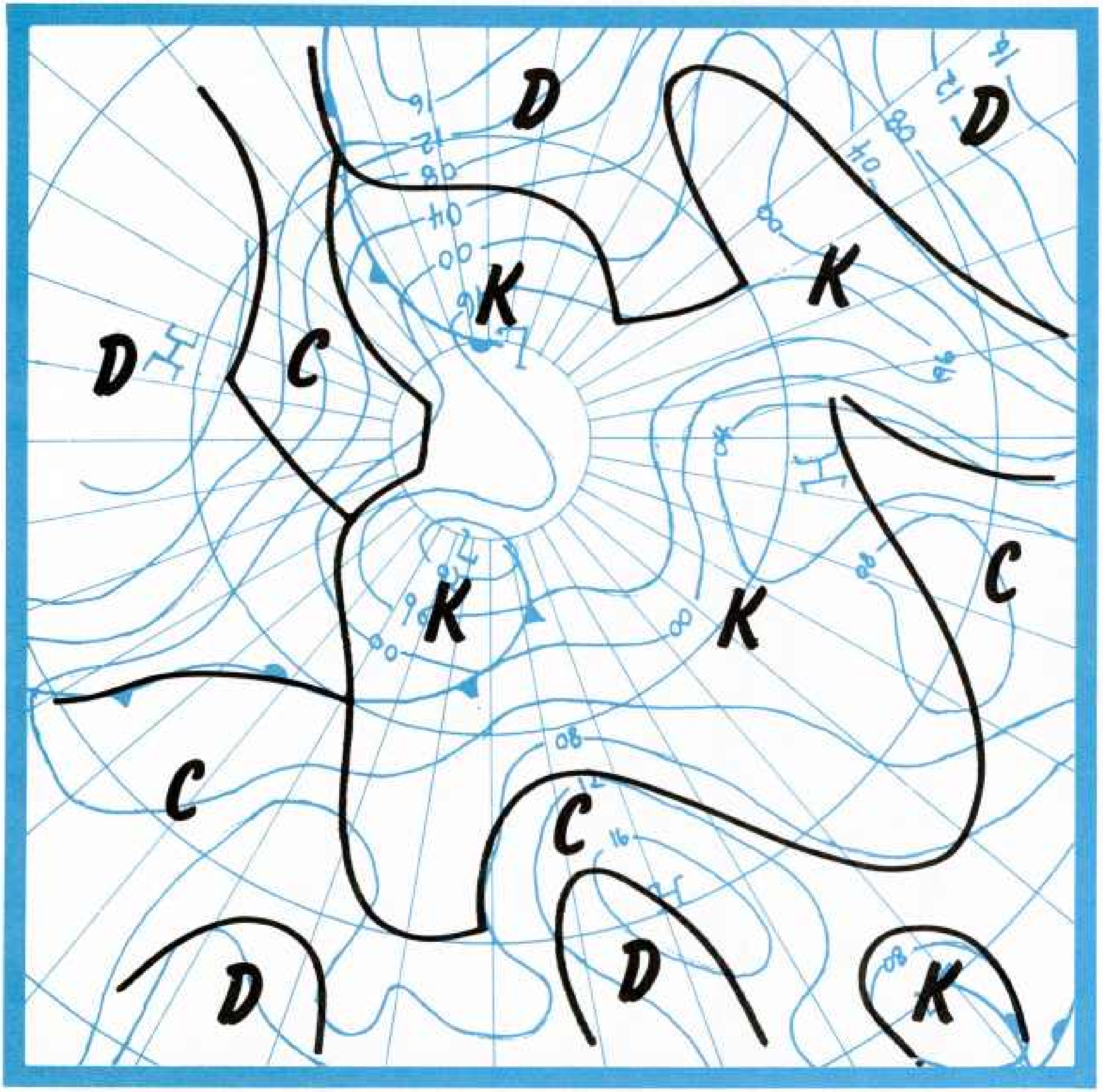

South Atlantic, Fall. Deep low with trailing frontal system over southern areas. Strong highs to east and west.



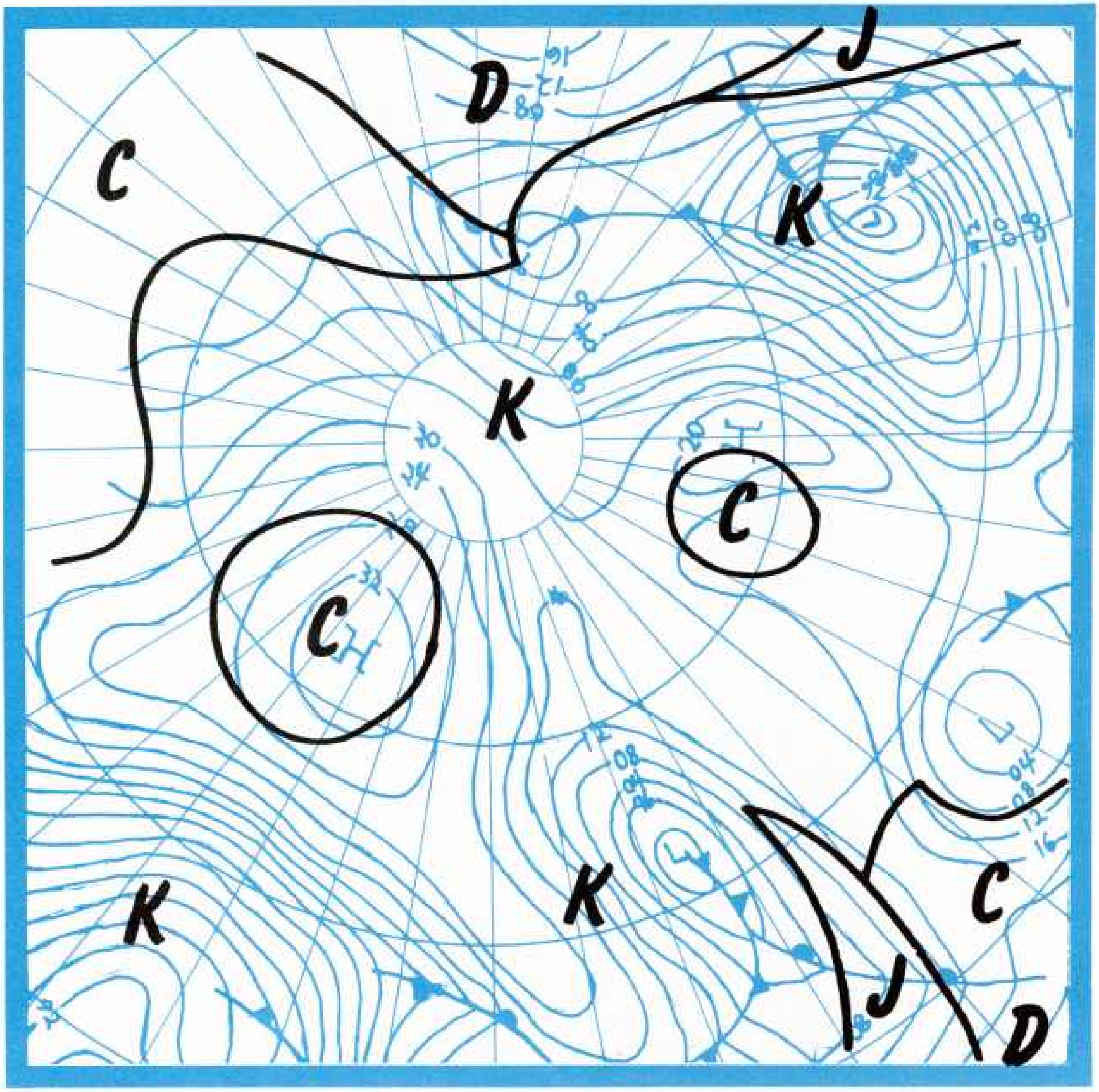

Arctic Ocean, Winter. Strong high near the pole with vigorous lows traversing southern areas.




Arctic Ocean, Spring. Strong high offset from the pole with moderate lows traversing extreme southern areas.




Arctic Ocean, Summer. Weak frontal systems rotate near the pole; high cells over extreme southern areas.




Arctic Ocean, Fall. High pressure near the pole with vigorous lows and frontal systems traversing southern regions.

# 5. PROFILES AND RAY TRACES

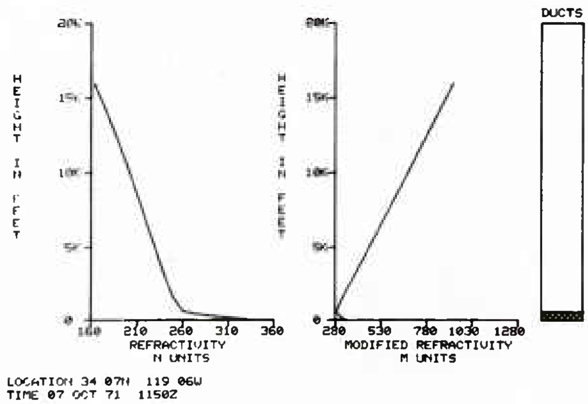
This section presents the 11 profile types selected for use in the REG procedure because of their significant refractive properties. Profile characteristics are cited, and sensor systems coverages that can be expected during profile conditions are described. The diagrams were generated by IREPS, and coverage descriptions are based on interpretations of them.

The diagrams include an "N" profile which shows how refractivity varies with altitude; an "M" (for modified) refractivity profile which is useful in determining duct locations for those users familiar with this method; and a duct height graph. On the right side of each profile page are several IREPS ray traces. These graphically indicate for each profile, the bending properties of sensor energy emitted at shallow angles from a number of different sensor altitudes. It should be noted by REG users that the further a sensor system is placed above or below a duct, the greater is the range to a radar hole.

Sensor system coverage descriptions are provided for surface-to-surface (S-S), surface-to-air (S-A), and air-to-air (A-A) situations. It is assumed that the transmitter is placed at the first location and the receiver or target at the second location (e.g., S-A = transmitter at surface and receiver/target airborne).

## PROFILE TYPE A

Intense surface-based duct with top near 600 feet. Very strong surface-based temperature inversion. Subtropical air mass.

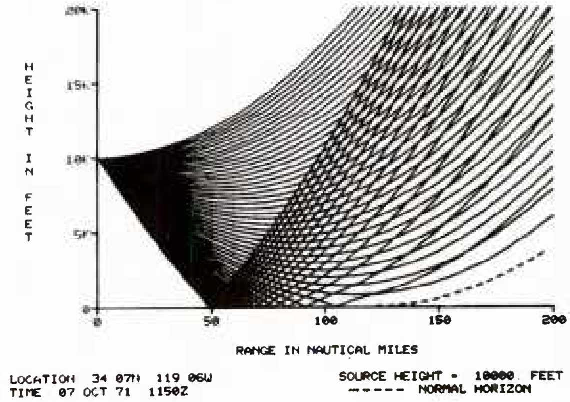


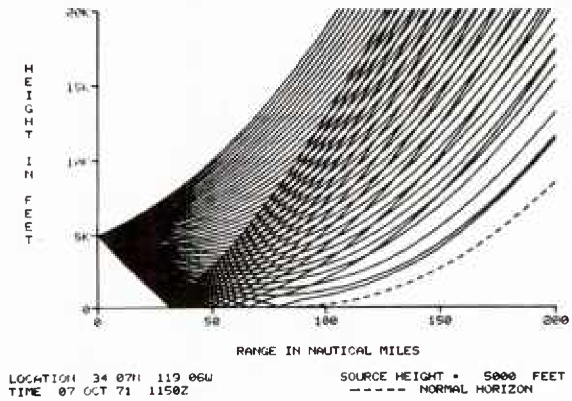

## SYSTEMS COVERAGE

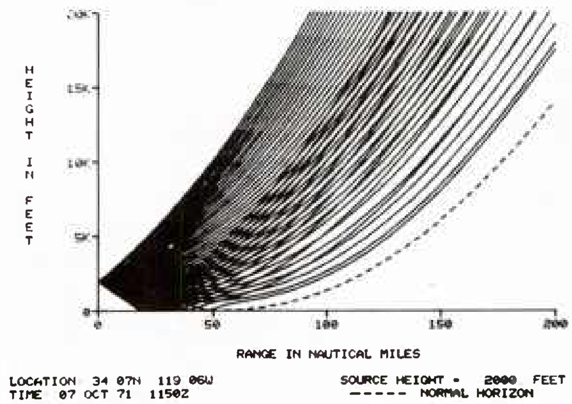
S-S Ducting and greatly extended range.

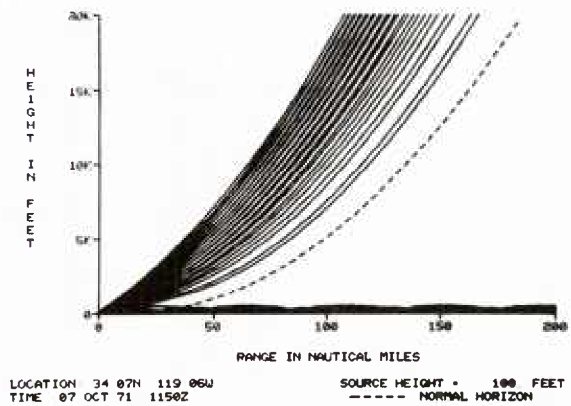
S-A Reduced range.

A-A Near normal for systems located well above duct. Some holes and fading for systems slightly above duct. Ducting, holes and fading possible for systems within duct (below 600 feet).



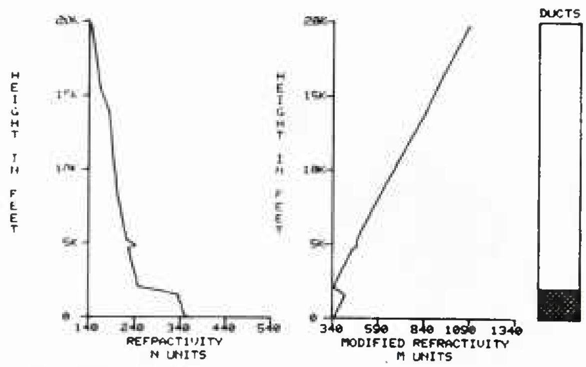



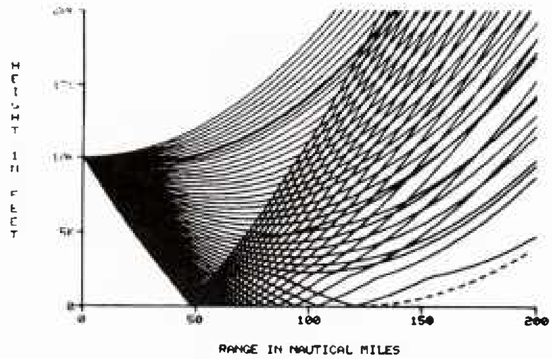



## PROFILE TYPE B

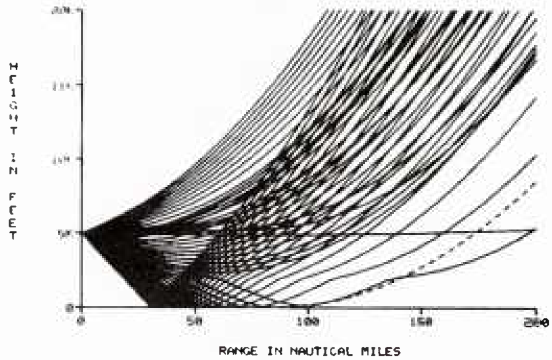
Very strong surface-based duct with top near 2,000 feet. Moderate elevated temperature inversion. Subtropical air mass.




LOCATION 34 07N 119 06W
TIME 26 JUL 74 1610Z




LOCATION 34 07N 119 06W
TIME 26 JUL 74 1610Z
SOURCE HEIGHT = 10000 FEET
----- NORMAL HORIZON



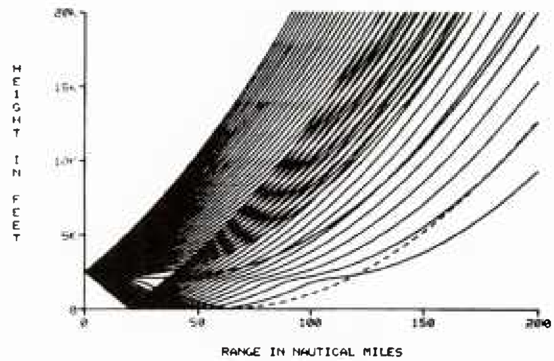

LOCATION 34 07N 119 06W
TIME 26 JUL 74 1610Z
SOURCE HEIGHT = 5000 FEET
----- NORMAL HORIZON

## SYSTEMS COVERAGE

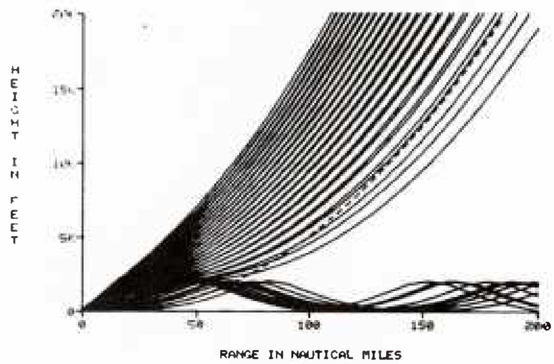
S-S Ducting and greatly extended range.

S-A Slightly extended range.

A-A Near normal for systems well above duct. Some holes and fading for systems slightly above duct. Ducting, holes and fading possible for systems within duct (below 2,000 feet).



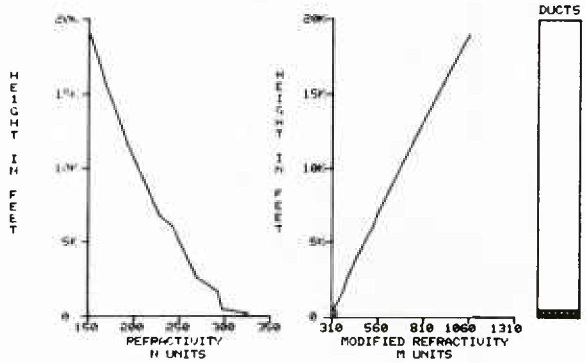

LOCATION 34 07N 119 06W
TIME 26 JUL 74 1610Z
SOURCE HEIGHT = 2500 FEET
----- NORMAL HORIZON




LOCATION 34 07N 119 06W
TIME 26 JUL 74 1610Z
SOURCE HEIGHT = 100 FEET
----- NORMAL HORIZON

## PROFILE TYPE C

Very low duct based at or just above surface with top near 600 feet. Strong surface-based temperature inversion. Polar air mass.



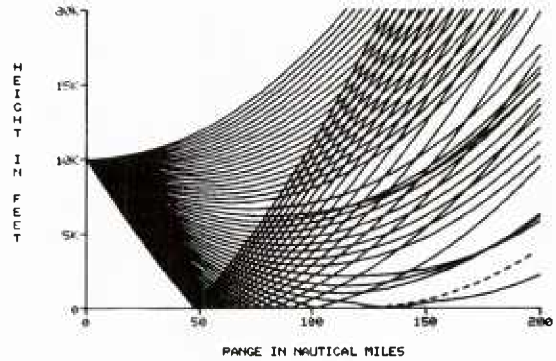

LOCATION 71 18N 156 47W
TIME 15 JUL 74 1115Z

## SYSTEMS COVERAGE

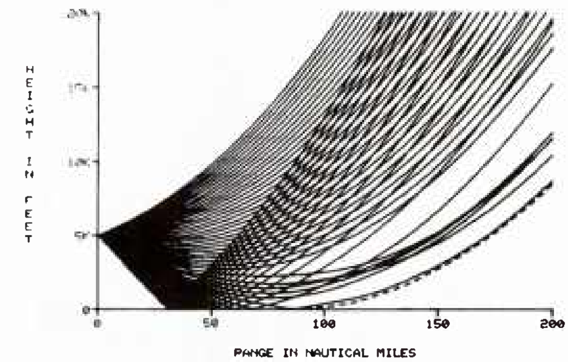
S-S Ducting and greatly extended range.

S-A Near normal.

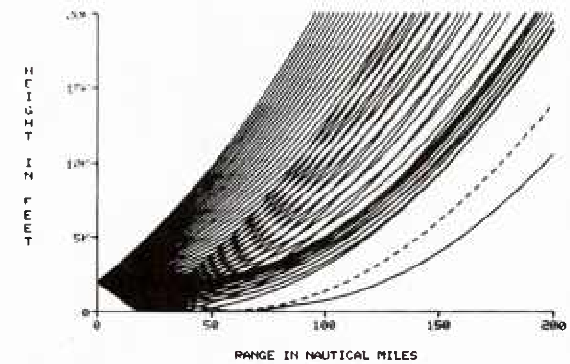
A-A Near normal for systems well above duct. Some holes and fading for systems slightly above duct. Ducting, holes and fading possible for systems within duct (below 600 feet).



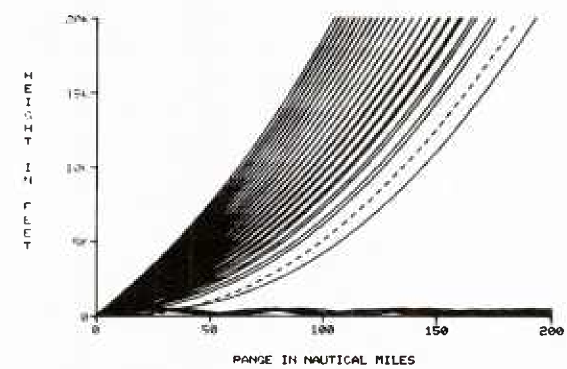

LOCATION 71 18N 156 47W
TIME 15 JUL 74 1115Z
SOURCE HEIGHT = 10000 FEET
----- NORMAL HORIZON




LOCATION 71 18N 156 47W
TIME 15 JUL 74 1115Z
SOURCE HEIGHT = 5000 FEET
----- NORMAL HORIZON



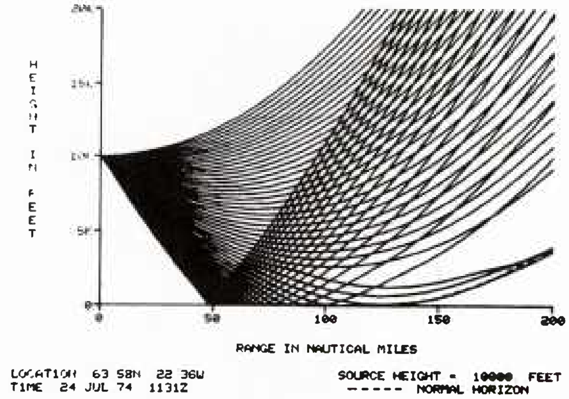

LOCATION 71 18N 156 47W
TIME 15 JUL 74 1115Z
SOURCE HEIGHT = 2000 FEET
----- NORMAL HORIZON

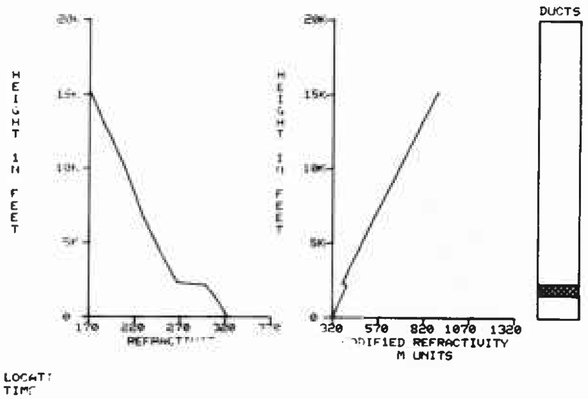


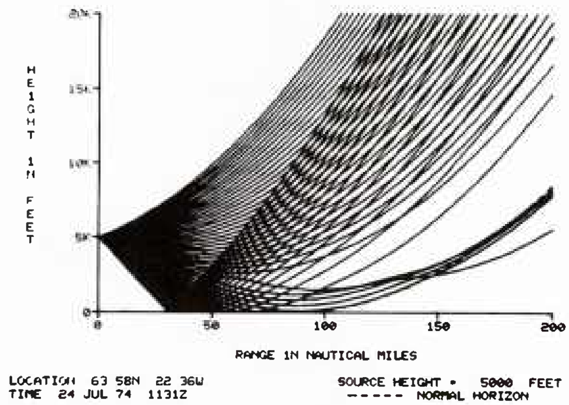

LOCATION 71 18N 156 47W
TIME 15 JUL 74 1115Z
SOURCE HEIGHT = 100 FEET
----- NORMAL HORIZON

## PROFILE TYPE D

Sharp elevated duct based near 1,500 feet with top at 2,300 feet. Moderate elevated temperature inversion. Modified polar air mass.



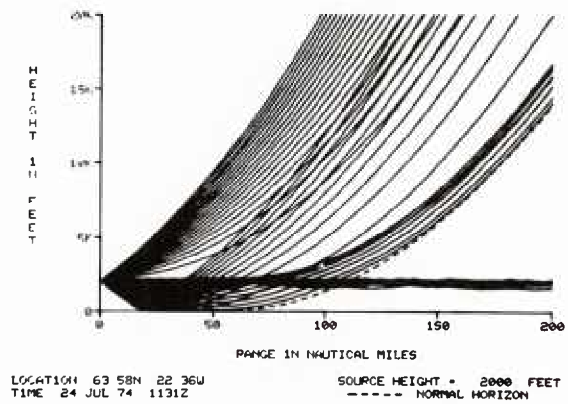



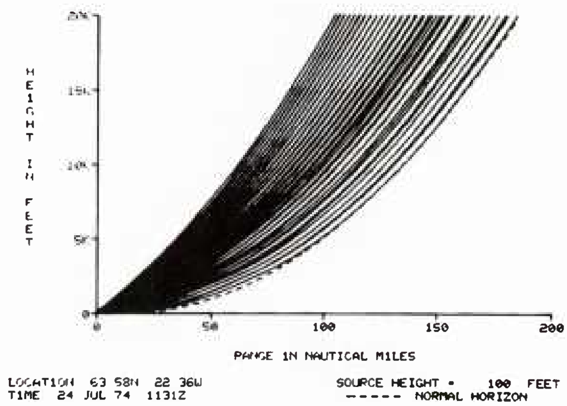

## SYSTEMS COVERAGE

S-S Normal.

S-A Normal.

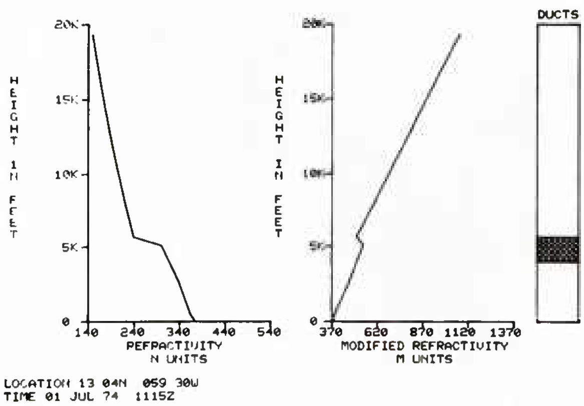
A-A Holes and fading possible for systems up to 10,000 feet. Ducting also possible for systems between 1,500 and 2,300 feet.



# PROFILE TYPE E

Sharp, deep, elevated duct based near 4,000 feet with top at 5,700 feet. Strong elevated temperature inversion. Tropical air mass.

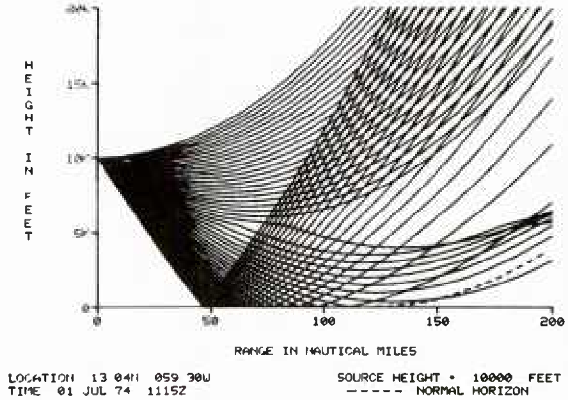


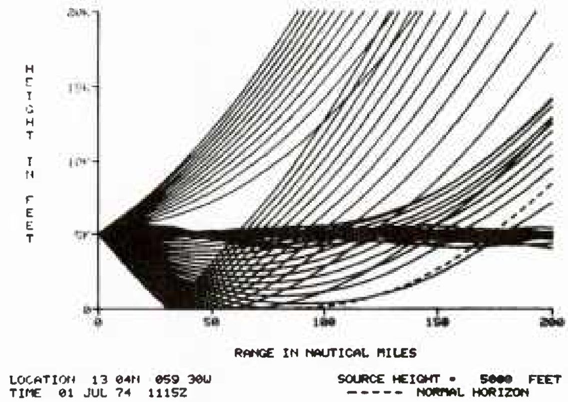

# SYSTEMS COVERAGE

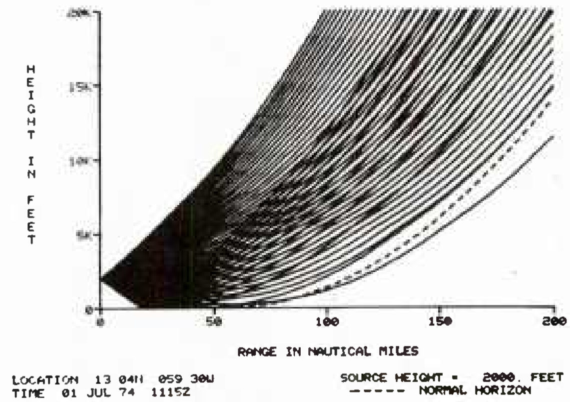
S-S Normal.

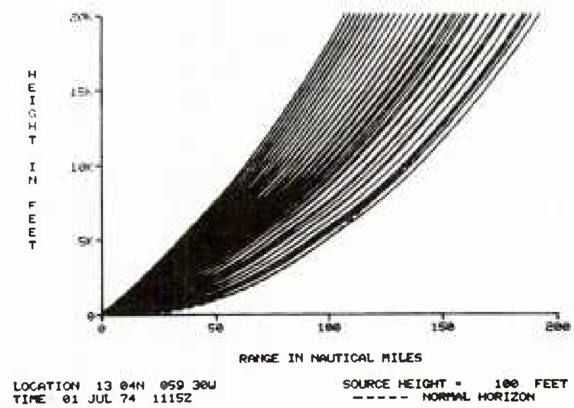
S-A Normal.

A-A Holes and fading possible for systems from about 3,000 to about 15,000 feet. Ducting also possible for systems between 4,000 and 5,700 feet. Near normal for systems below 3,000 feet and above 15,000 feet.



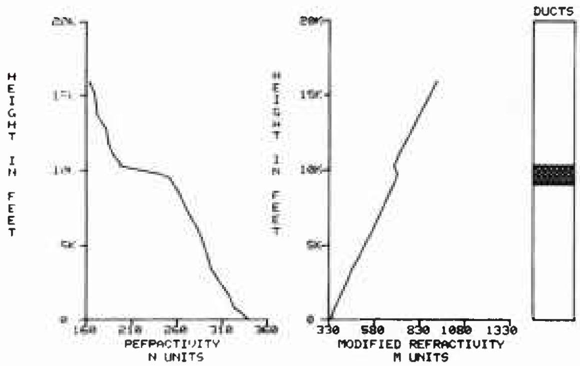



## PROFILE TYPE F

Very sharp, high, elevated duct based near 9,200 feet with top near 10,300 feet. Modified tropical air mass.




LOCATION 22 02N 159 47W WIND SPEED 0 0 KNOTS
TIME 25 JUL 69 1810Z

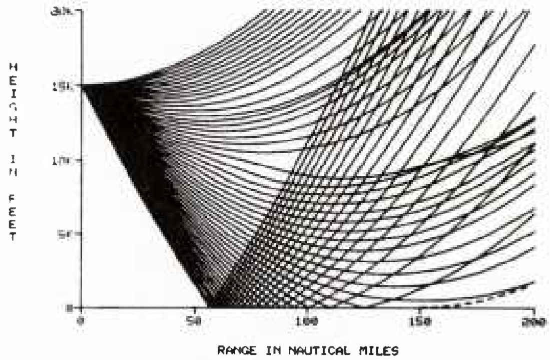
(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?

## SYSTEMS COVERAGE

S-S Normal.

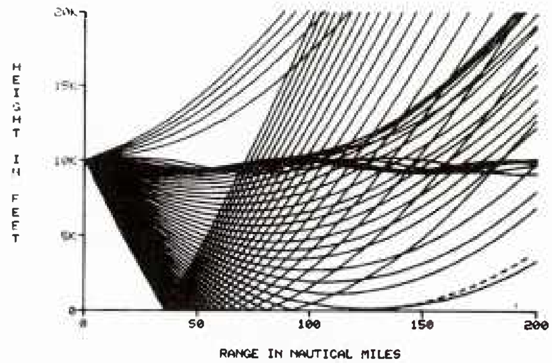
S-A Normal.

A-A Holes and fading possible for systems between 5,000 and 17,000 feet. Ducting also possible for systems between 9,200 and 10,300 feet. Near normal for systems below 5,000 feet and above 17,000 feet.



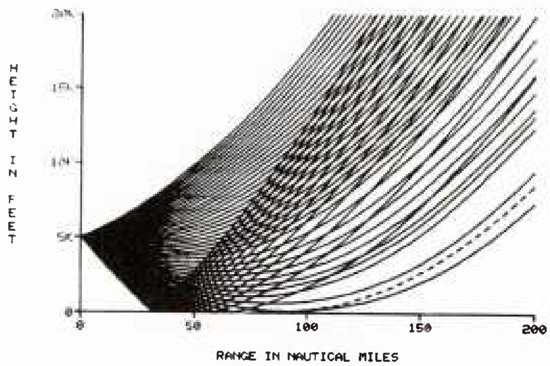

LOCATION 22 02N 159 47W SOURCE HEIGHT = 15000 FEET
TIME 25 JUL 69 1810Z ----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?



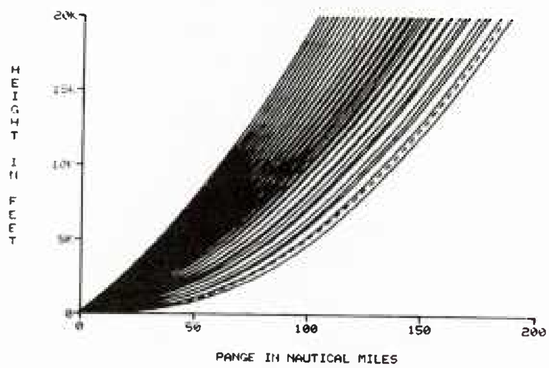

LOCATION 22 02N 159 47W SOURCE HEIGHT = 10000 FEET
TIME 25 JUL 69 1810Z ----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?




LOCATION 22 02N 159 47W SOURCE HEIGHT = 5000 FEET
TIME 25 JUL 69 1810Z ----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?

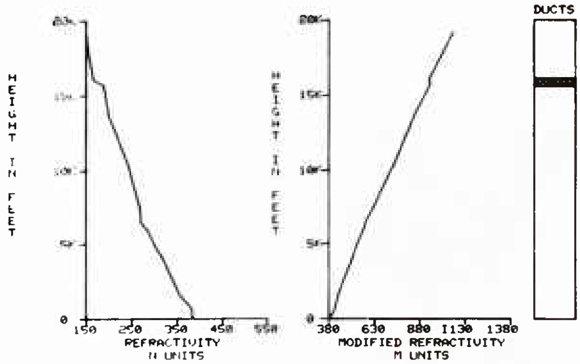



LOCATION 22 02N 159 47W SOURCE HEIGHT = 100 FEET
TIME 25 JUL 69 1810Z ----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?

## PROFILE TYPE G

Very high elevated duct based near 15,500 feet with top near 16,200 feet. Slight elevated temperature inversion. Modified tropical air mass.




LOCATION 08 59N 079 33W    WIND SPEED 0 0 KNOTS
TIME 07 JAN 74 1116Z

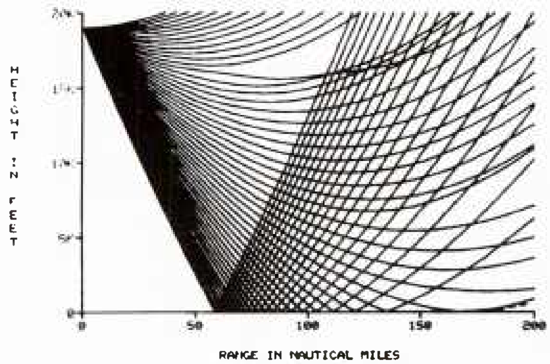
(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?

## SYSTEMS COVERAGE

S-S Normal.

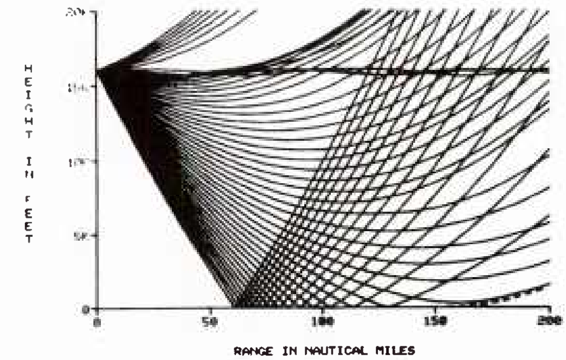
S-A Normal.

A-A Holes and fading possible for systems between 8,000 and 20,000 feet. Ducting also possible for systems between 15,500 and 16,200 feet. Near normal for systems below 8,000 feet and above 20,000 feet.



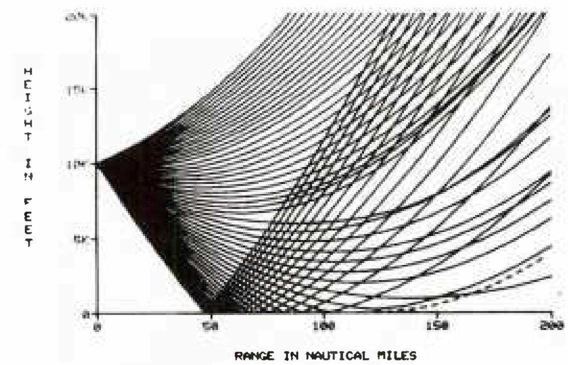

LOCATION 08 59N 079 33W    SOURCE HEIGHT = 19000 FEET
TIME 07 JAN 74 1116Z    ----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?



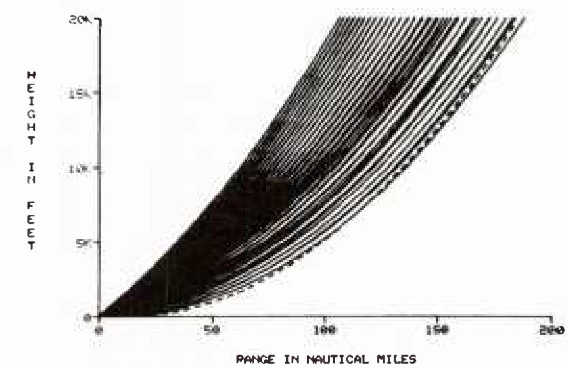

LOCATION 08 59N 079 33W    SOURCE HEIGHT = 16000 FEET
TIME 07 JAN 74 1116Z    ----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?




LOCATION 08 59N 079 33W    SOURCE HEIGHT = 10000 FEET
TIME 07 JAN 74 1116Z    ----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?

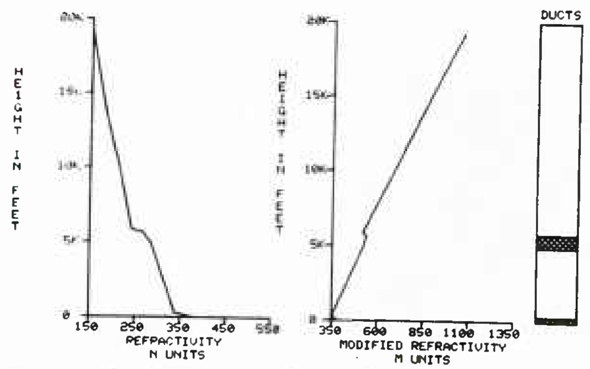



LOCATION 08 59N 079 33W    SOURCE HEIGHT = 100 FEET
TIME 07 JAN 74 1116Z    ----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?

## PROFILE TYPE H

Multiple ducts with bases at surface and about 5,000 feet and tops at 300 and 5,900 feet. No temperature inversions. Tropical air mass.




LOCATION 14 20S 170 43W
TIME 10 JAN 74 2315Z
WIND SPEED 0 0 KNOTS

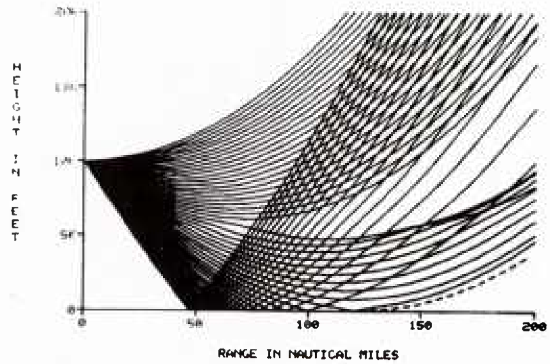
(PLOT.EDIT.LIST.SUMRY.RAYS LOSS.COVER.END)?

## SYSTEMS COVERAGE

S-S Ducting and greatly extended range.

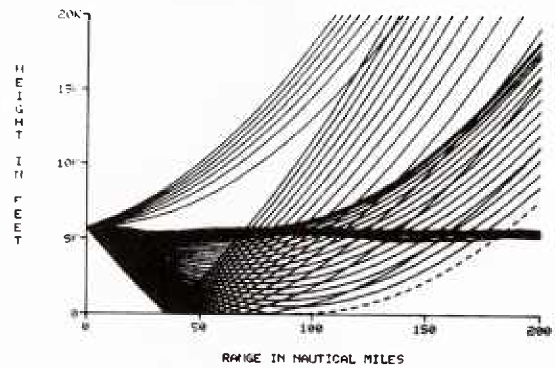
S-A Slightly reduced range.

A-A Some holes and fading for systems up to 12,000 feet. Ducting also possible for systems between the surface and 300 feet and between 5,000 and 5,900 feet. Anomalous propagation may be experienced at several altitudes.



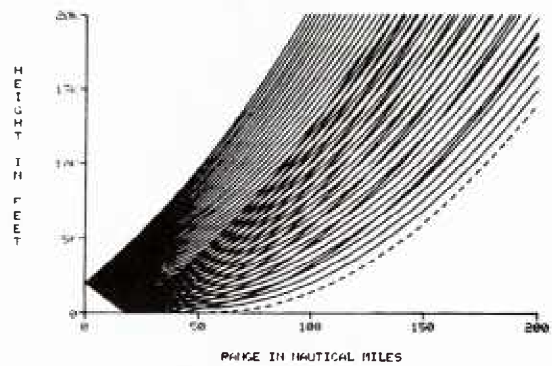

LOCATION 14 20S 170 43W
TIME 10 JAN 74 2315Z
SOURCE HEIGHT = 10000 FEET
----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?



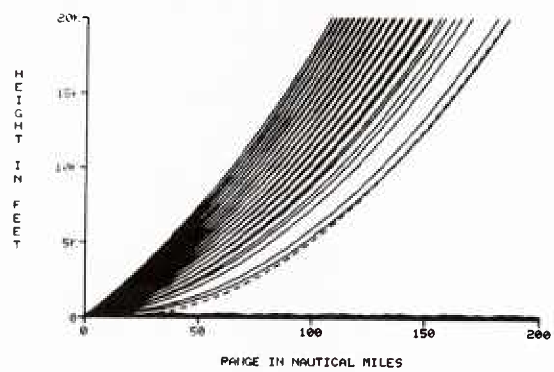

LOCATION 14 20S 170 43W
TIME 10 JAN 74 2315Z
SOURCE HEIGHT = 5700 FEET
----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?




LOCATION 14 20S 170 43W
TIME 10 JAN 74 2315Z
SOURCE HEIGHT = 2000 FEET
----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?

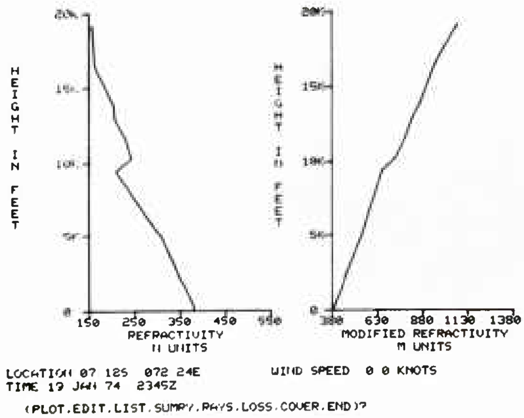



LOCATION 14 20S 170 43W
TIME 10 JAN 74 2315Z
SOURCE HEIGHT = 100 FEET
----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?

## PROFILE TYPE I

Very strong elevated sub-refractive layer due to strong increase in moisture at higher levels (from 9,400 to 10,300 feet). Tropical air mass.

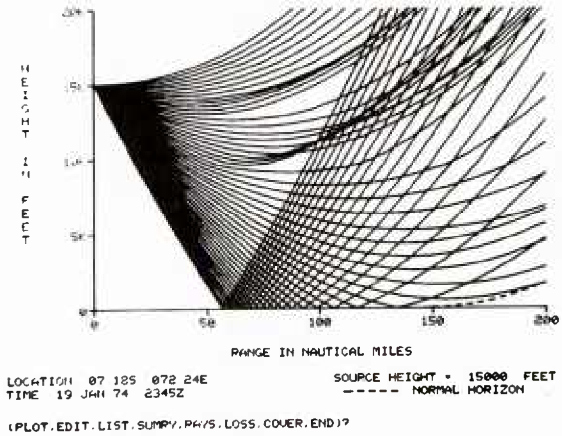


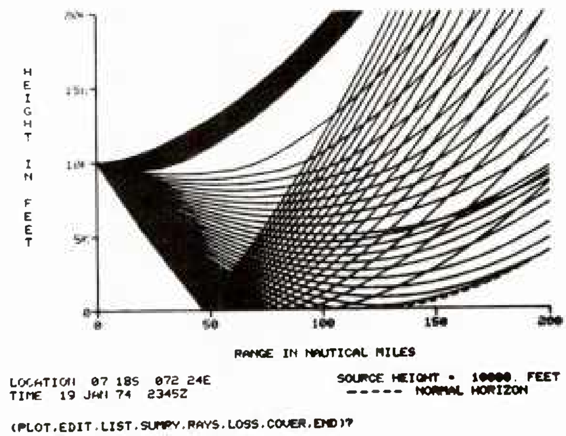

## SYSTEMS COVERAGE

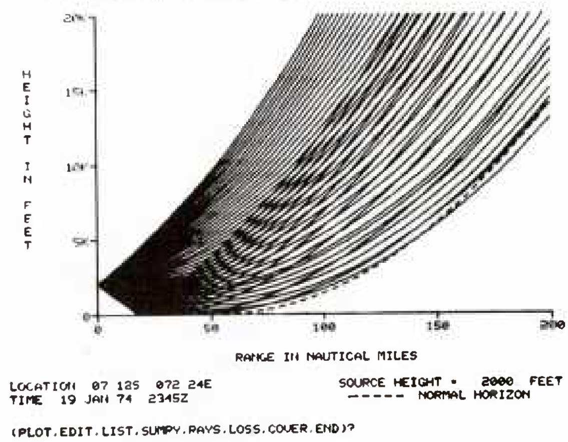
S-S Normal.

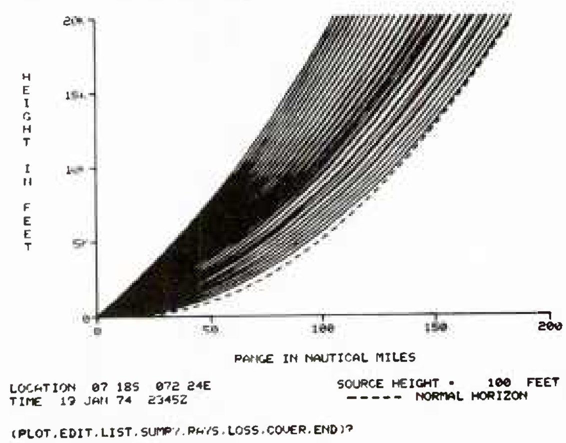
S-A Normal

A-A Holes and fading possible for systems between 7,000 and 17,000 feet. Near normal for systems below 7,000 and above 17,000 feet.



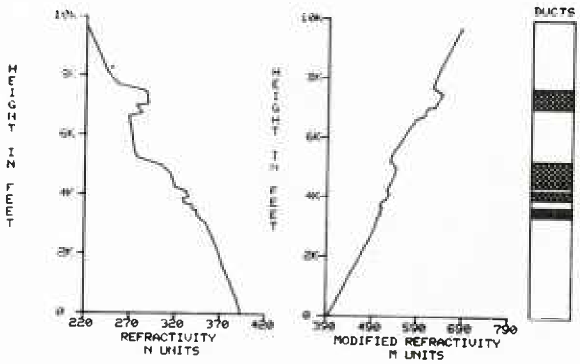



## PROFILE TYPE J

Multiple ducts and subrefractive layers up to 8,000 feet. Modified tropical air mass.




LOCATION 21 15N 159 00W
TIME 23 JUL 69 0035Z
WIND SPEED 0 0 KNOTS

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?

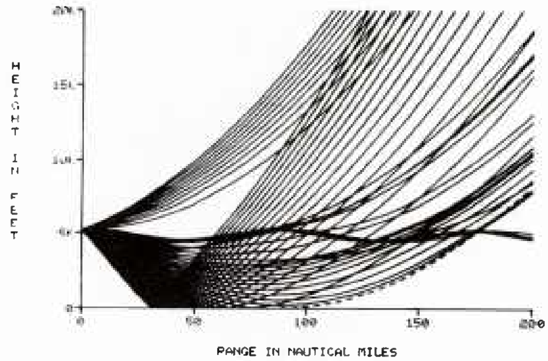
## SYSTEMS COVERAGE

S-S Normal.

S-A Normal.

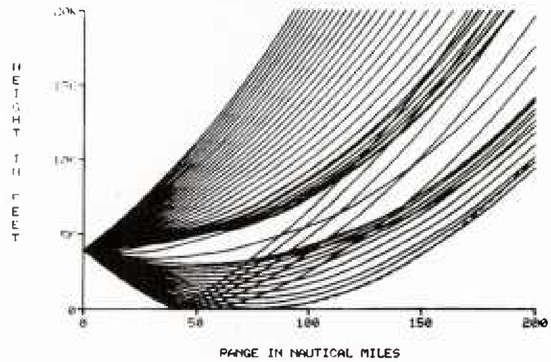
A-A Ducting, holes and fading possible for systems up to 15,000 feet. Anomalous propagation may be experienced at several altitudes.

Note: Profile Type J ray traces continued on following page.



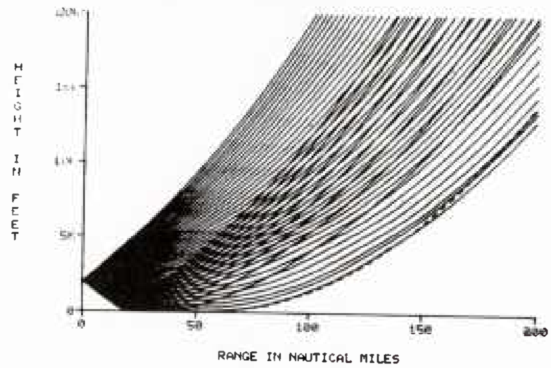

LOCATION 21 15N 159 00W
TIME 23 JUL 69 0035Z
SOURCE HEIGHT = 5200 FEET
----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?



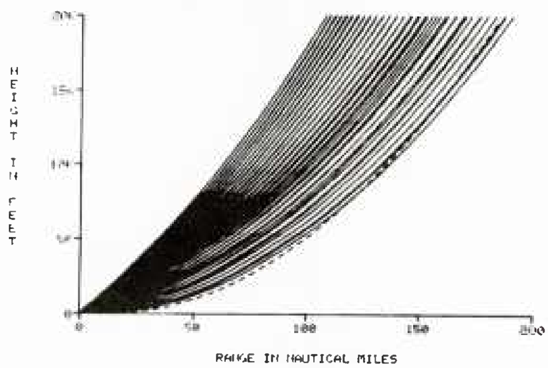

LOCATION 21 15N 159 00W
TIME 23 JUL 69 0035Z
SOURCE HEIGHT = 3900 FEET
----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?




LOCATION 21 15N 159 00W
TIME 23 JUL 69 0035Z
SOURCE HEIGHT = 2000 FEET
----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?

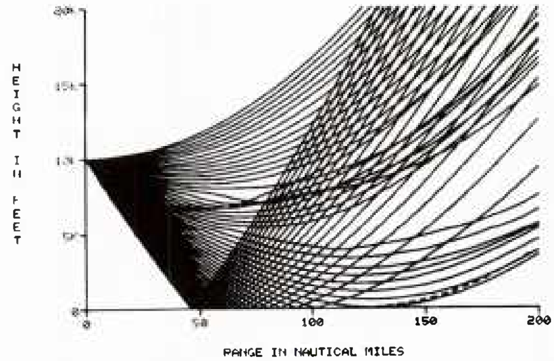



LOCATION 21 15N 159 00W
TIME 23 JUL 69 0035Z
SOURCE HEIGHT = 100 FEET
----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?

## PROFILE TYPE J

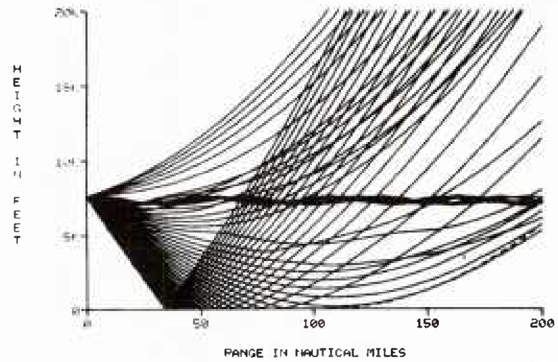
Ray Traces (Continued)




LOCATION 21 15N 159 00W
TIME 23 JUL 69 0035Z

SOURCE HEIGHT = 10000 FEET
----- NORMAL HORIZON

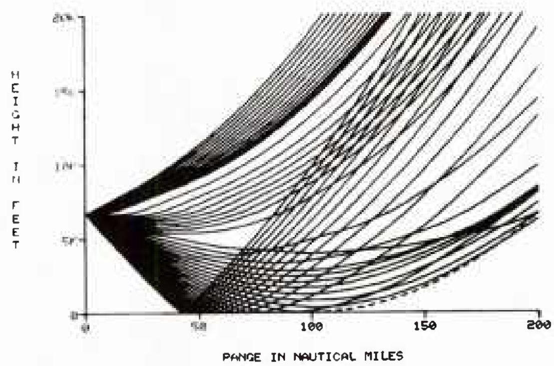
(PLOT.EDIT.LIST.SUMPY.RAYS.LOSS.COVEP.END)?




LOCATION 21 15N 159 00W
TIME 23 JUL 69 0035Z

SOURCE HEIGHT = 7600 FEET
----- NORMAL HORIZON

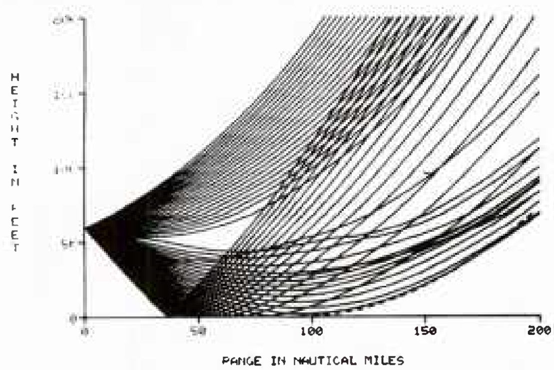
(PLOT.EDIT.LIST.SUMPY.RAYS.LOSS.COVER.END)?




LOCATION 21 15N 159 00W
TIME 23 JUL 69 0035Z

SOURCE HEIGHT = 6700. FEET
----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMPY.RAYS.LOSS.COVER.END)?



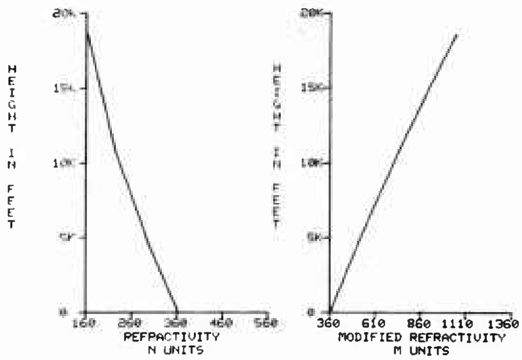

LOCATION 21 15N 159 00W
TIME 23 JUL 69 0035Z

SOURCE HEIGHT = 6000 FEET
----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMPY.RAYS.LOSS.COVER.END)?

## PROFILE TYPE K

Standard well-mixed atmosphere. No significant refractive layers. Temperate air mass.




LOCATION 30 00N 140 00W WIND SPEED 0 0 KNOTS
TIME 09 JAN 74 2245Z

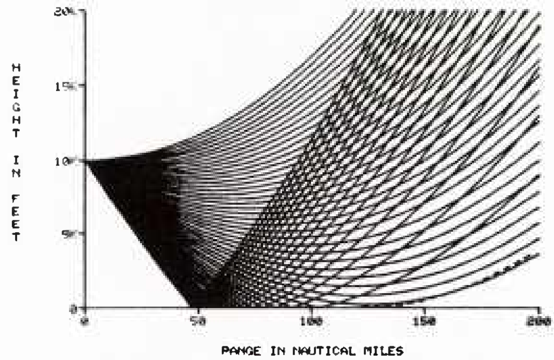
(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?

## SYSTEMS COVERAGE

S-S Normal.

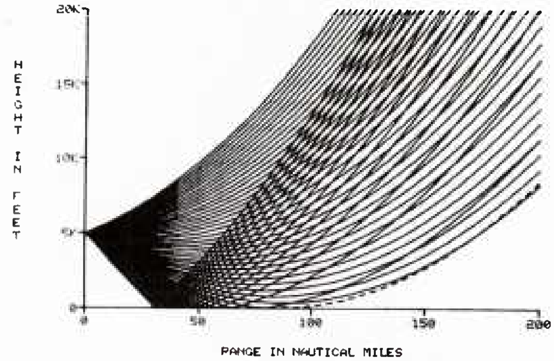
S-A Normal.

A-A Normal.



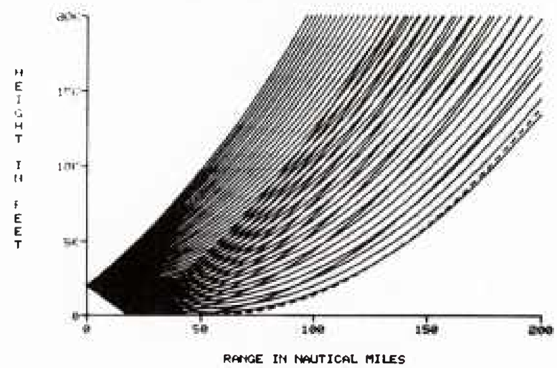

LOCATION 30 00N 140 00W SOURCE HEIGHT - 10000 FEET
TIME 09 JAN 74 2245Z ----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?



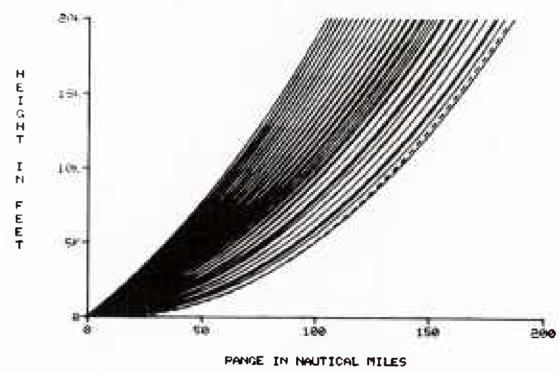

LOCATION 30 00N 140 00W SOURCE HEIGHT - 5000 FEET
TIME 09 JAN 74 2245Z ----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?




LOCATION 30 00N 140 00W SOURCE HEIGHT - 2000 FEET
TIME 09 JAN 74 2245Z ----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?




LOCATION 30 00N 140 00W SOURCE HEIGHT - 100 FEET
TIME 09 JAN 74 2245Z ----- NORMAL HORIZON

(PLOT.EDIT.LIST.SUMRY.RAYS.LOSS.COVER.END)?

**UNITED STATES PACIFIC FLEET**
COMMANDER THIRD FLEET
FPO SAN FRANCISCO 96610

IN REPLY REFER TO:
FF/3
3161
Ser N33/1374
22 September 1976

From: Commander THIRD Fleet
To: Distribution

Subj: COMTHIRDFLT Tactical Memorandum 280-1-76

Ref: (a) NWP 0
(b) CINCPACFLTINST 3510.2L
(c) COMTHIRDFLT TACMEMO 280-2-75 AD-C002 786

Encl: (1) COMTHIRDFLT TACMEMO 280-1-76, REFRACTIVE EFFECTS GUIDEBOOK (REG)

1. TACMEMO 280-1-76 is forwarded as enclosure (1) in accordance with references (a) and (b). The TACMEMO contains improved guidelines for exploiting the effects of atmospheric refraction on electromagnetic propagation. Procedures are provided for converting routine weather information received aboard ship to a measure of anticipated system performance. Although the guidelines and procedures are based on a number of simplifying assumptions, the REG is considered a step forward in the documentation of tactical exploitation of refractive effects.

2. Reference (c), "Interim Guidelines for Using Atmospheric Refractive Effects," is superseded and cancelled.

3. The essence of the REG is contained in Chapters 4 and 5. Once the appropriate refractive profile has been determined from Chapter 4, the decision maker will find all the applicable information concerning that profile on a single page in Chapter 5. The remaining chapters provide background information and instructions for use.

4. This TACMEMO will be revised as necessary. Lessons learned and recommendations are desired from all users, who are requested to forward significant case histories, with supporting environmental data when available, for analysis. Such reports should be forwarded to Commanding Officer, Naval Environmental Prediction Research Facility, with copy to Commander THIRD Fleet and Commanding Officer, Pacific Missile Test Center (Code 3253).

S. L. GRAVELY, JR.

Distribution:
(See TACMEMO 280-1-76, Page i)

ERRATA

COMTHIRDFLT TACMEMO 280-1-76

The following page numbers should be added by pen-and-ink:

| Page Title | Page Number |
| --- | --- |
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| Preface | iv |

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